United States
Department of
Agriculture

Forest Service

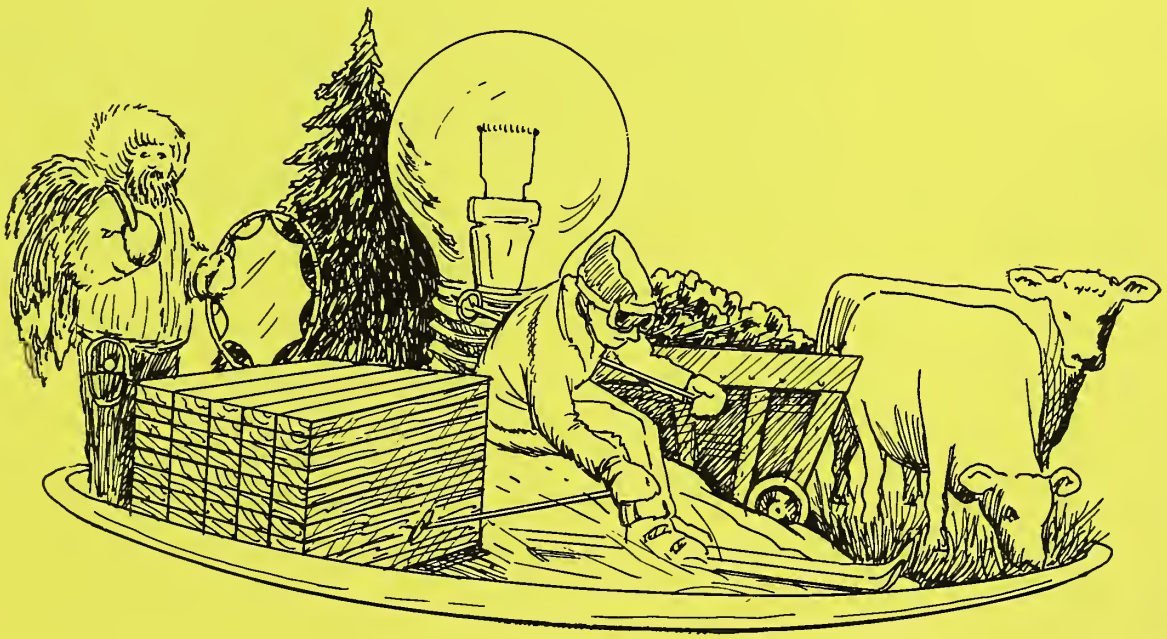
**Rocky Mountain
Forest and Range
Experiment Station**

Fort Collins,
Colorado 80526

**General Technical
Report RM-148**

Toward the Measurement of Total Economic Value

George L. Peterson and Cindy F. Sorg



Abstract

Considerable progress has been made in recent years in the valuation of non-priced goods. However, emphasis has been on those things most readily measurable. Valuation of wildlife benefits, for example, has aimed at consumptive, on-site recreation use (i.e., hunting and fishing). The danger in these partial estimates of value is that measuring only the on-site consumptive use of wildlife may presume to measure total value. This report examined the task of measuring of-site non-consumptive wildlife vaues by considering values that include: total vlaue, option value, existence value, quasi-option value, and bequest value. Discrepancies in definitions, measurement problems, and research needs are addressed in this collection of papers.

USDA Forest Service
General Technical Report RM-148

November 1987

Toward the Measurement of Total Economic Value

George L. Peterson and Cindy F. Sorg[1]

[1]Peterson is Project Leader, and Sorg is Economist, at the Rocky Mountain Forest and Range Experiment Station. Station headquarters is in Fort Collins, in cooperation with Colorado State University.

Contents

Page

Toward the Measurement of Total Economic Value

George L. Peterson and Cindy F. Sorg

In a free economy there are three ways to decide how to allocate resources. One is market equilibrium; another is political equilibrium; the third is benefit cost analysis (BCA). In the first method, people bargain with each other to exchange goods and services within a framework of established economic rights and rules. The second method is a non-violent means of collective decisions, resolving conflicts, and distributing wealth. The outcomes of markets and politics are "sovereign," because they result from free choices of individuals. The third method, benefit-cost analysis, is a technical simulation of market equilibrium that attempts to correct market imperfection resulting from failure of imperfect competition. It provides reasoned information about the economic efficiency of alternative choices.

"BCA" is used often, in some form, whenever a choice must be made. Its applications are the most formal and demanding when assessing action by government to regulate the market or to supply goods and services directly. BCA attempts to evaluate the economic efficiency of various government proposals by estimating and summing all the costs and benefits, so that the net gain in aggregate wealth with vs. without a proposal can be measured.

In theory government action is needed where externality and monopoly create inefficient market choices. A market seeks equality of the producers' marginal revenue and marginal cost -- that point at which one more unit of production earns less income than its cost. The aggregate wealth of society is greatest, however, when marginal willingness to pay equals marginal cost -- that point at which the monetary value of the benefit to society from one more unit of production equals its cost to society. The two are identical where externality and monopoly are absent and transaction costs are zero. Then, the free market serves the best interest of society by serving the best interest of each individual separately.

However, there are "slippery" goods that evade market choices, and are non-rival or non-excludable in consumption. Thus, they produce costs and benefits which are ignored by private firms and market transactions; the result is disparity between market equality and maximum aggregate wealth. Similarly benefits one at the expense of society. Therefore, by political choices, government regulates some industries and even supplies some goods and services itself.

Theoretically, the task of BCA is to specify the societal marginal willingness to pay (i.e., demand) functions and the societal marginal cost functions, then solve the resulting set of simultaneous equations to allocate resources optimally. However, these equations have not been written. Until they are, the best that can be done is to design discrete choices and compare them by estimating their costs and benefits. Although there may be a tendency to think of these costs and benefits in terms of quantities and prices, major government action may have non-marginal consequences, making the concept of a simple price meaningless, unless it is the price of the whole change, in contrast to a common price of the different elements of change.

Market prices may be distorted by the conditions government is trying to correct, and even by the government action itself. Furthermore, government is involved because markets cannot set meaningful prices for many of the changes. Therefore government cannot make decisions using the same criteria used by private firms.

Much progress has been made in recent years in the valuation of non-priced and non-priceable goods. However, emphasis has been on those things most readily measurable. Valuation of wildlife benefits, for example, has aimed at consumptive, on-site recreational use (i.e., hunting and fishing). While the results are not without controversy, economists have estimated values for activities such as hunting and fishing. These values are consistent in independent research efforts.

The danger in partial estimates of value is that measuring only the on-site consumptive use of wildlife may presume to measure total value. Killing and eating animals or hanging them on the wall are not the only ways wild animals contribute value. For example, people visit zoos, attend wildlife movies, and buy books about wild animals. Viewing animals in their natural habitats provides enjoyment for many people, and is a major attraction to some national parks. This is a cost which may suggest some value(s), but is not a value itself. This is done for reasons closer to being or suggesting values than the costs are.

There are two ways to include nonconsumptive values in the decisionmaking process. One is through political action. The other is to devise ways to measure them scientifically and include them in BCA. If these other values are not included in BCA, the results of BCA are incomplete, and the conclusions invalid. However, there is not unanimous agreement that such values are measurable. Some would argue that the best we can do is show the consequences and let the political system reach its own conclusions. However, because BCA is widely used to evaluate public projects, it is imperative to attempt to measure and include the nonconsumptive values.

This report examines the task of measuring off-site non-consumptive wildlife values. Alan Randall discusses "The Total Value Dilemma." Any proposed action affecting the supply of wildlife may affect several components of demand. A given individual may have several different objectives or concerns related to the change in wildlife. These concerns generate willingness to pay (or compensation demanded) for the change. Can the separate components of value be identified and measured independently, or is it more meaningful to measure the total value of the change? Evaluation of some management actions may require separation of the components. Also, there may be instances where the off-site non-consumptive values may be dominant in a given decision. Randall develops a conceptual framework for defining and estimating total value.

David Brookshire, Larry Eubanks, and Cindy Sorg look at "Existence Values and Normative Economics" by first noting discrepancies in definitions and measurements of existence value within and across research studies. Then they consider whether the nature of the values conflicts with the normative base of the benefit-cost framework regardless of consensus in terminology. Perhaps elements of existence value are based upon non-efficiency considerations, and, therefore, are not conducive to a BCA criterion.

V. Kerry Smith discusses "Intrinsic Values in Benefit Cost Analysis." He argues that option, existence, and bequest value are concepts consistent with established models of consumer choice, but suggests the theoretical framework is not well-developed, and there is consequent possibility to ignore such values or to exploit them in the justification of proposals. Smith defines these components of value and shows where they fit in modern consumer theory. He also discusses the prospects for measurement and explores the policy implications.

In the last paper, Richard Bishop concentrates on uncertainty in resource valuation. He reviews the theoretical literature on option value as a guide for empirical research. Bishop examines the theoretical definitions needed to allow measurement of welfare change under uncertainty with emphasis on "option price" and "quasi-option value."

Some progress has been made here toward a consistent theoretical framework that integrates elusive components of value into the general theory of economic efficiency. More theoretical refinement is needed, and the move towards collection of empirical data will be difficult. Much research is needed before estimates of option, existence, and bequest value can enjoy the same credibility as market prices or even on-site values measured by travel cost analysis and the Contingent Value Method.

Major effort is needed in at least four areas. First, the concepts need to be part of a consensus of economic theory. The kinds of values and observation processes involved need to be clearly defined. Second, the objects to which value is to be assigned need to be defined better. Value greatly depends on the context. "Existence value" is only a partial term; the phrase "existence value of - - - - -" needs to be completed.

Third, more knowledge is needed about how people perceive and think about things. Economic value is a concept of exchange under threat of exclusion (i.e., an inherently market phenomenon). It depends on (1) the strength of the individuals' "value" on the function performed, and (2) the "value" in exchange as determined by the market context. It may be difficult for people to think in market terms about things they have never experience in that context, or things that inherently cannot be experienced in a market context of exchange and exclusion. To get a valid response, economists should draw upon other disciplines, especially psychology.

Fourth, an empirical history is needed. Certification of reliability and validity in the measurement of things such as option, existence, and bequest value require proven performance. Empirical experience, in turn, can lead to adoption of standard units and standard methods, further enhancing ability to make comparisons and generalizations.

From a broader perspective, economic efficiency, as defined in terms of micro-economic consumer theory, is normative and somewhat narrower. The extent to which scientific measurement of total value is used to make decisions will be determined by the political system. However, it should be determined whether those components of value can be measured, whether or where their magnitudes are significant, and whether decision processes are sensitive to these facts.

The Total Value Dilemma

Alan Randall[1]

Abstract--Total value may be measured directly, or component-by-component. The first-mentioned approach restricts estimation techniques to the contingent valuation method, while the second allows a wider range of estimation methods but encounters conceptual difficulties in formulating the relationship between total value and component values. This dilemma is elaborated, and some partial solutions are suggested.

The total value of some environmental asset can be estimated directly, using the contingent valuation method. The one-shot estimate of total value will be acceptable for benefit cost analysis, if reliable contingent valuation methods (CVM) can be designed and implemented. However, one-shot estimation of total value via non-CVM methods does not appear feasible.

Another approach to determining total value is to identify its components, estimate the value of each component using appropriate methods, and sum the component values according to rules consistent with the theoretically valid relationships among value components. This may permit use of estimation methods (such as the travel cost, property value, and hedonic methods) that use data obtained from transactions in markets for related goods and services to estimate benefits for some components of total value. For value components that can be estimated with CVM and non-CVM methods, there is the opportunity for validation by cross-technique comparison of results.

However, the "taxonomy of value components" approach encounters special difficulties. First, various inconsistencies and unresolved problems limit development of a coherent taxonomy of value components.[2] Without a coherent taxonomy, it is impossible to estimate correctly total value by summing the component values. Second, many of the value components that are identified in various taxonomies (e.g., existence value, option price, off-site or vicarious user values) are difficult to estimate using non-CVM methods. The "taxonomy of value components" approach allows non-CVM estimation methods -- for exclusive use, or for corroboration of CVM results -- for only some of the important value components, such as on-site use value. For other value components and for total value, CVM benefit estimates cannot be corroborated by estimates made with other methods.

This is the total value dilemma. Total value may be estimated directly by CVM; but this eliminates corroboration using other methods. On the other hand, the "taxonomy of value components" approach permits use of non-CVM methods for components; and valid summation of component value estimates to obtain total value will be impossible until a valid taxonomy is developed.

Reliance on CVM may not be as undesirable as once believed. There has been a greater recognition of the analytical difficulties in the non-CVM (e.g., weak complementarity or hedonic price theory) methods, while evidence that CVM is "working fairly well" has been accumulating.[3] Further, recent theoretical analyses suggest that it is possible to construct satisfactory CVM benefit estimators (Hoehn and Randall 1987). The imperative to use the "taxonomy of components" approach because it avoids total reliance on CVM is not as strong as it once was.

For some components of value (e.g., existence value and off-site or vicarious user value), there may be more opportunities than currently recognized for generating value-relevant information via methods other than CVM. Corroboration of CVM results with evidence generated independently of the CVM exercise may be possible in some broad classes of situations.

A Definition of Total Value

Consider an environmental asset capable of producing a time-stream of a single service $Q(t), 0 \leq t \leq \infty$, where t indi-

[1]Professor, Agricultural Economics and Rural Sociology, The Ohio State University, Columbus, Ohio.

[2]For example, Schmalensee (1972), Graham (1981), Bishop (1982), Bishop, (this volume), and Smith (this volume).

[3]For example, Randall et al. (1983), and Cummings et al. (1986).

cates time. If $V(t)_0$ is the aggregate value (across people) of Q(t), as anticipated at t = 0, the present value of this asset at that time is:

$$P_0 = \int_0^\infty V(t)_0 e^{-rt} dt, \qquad [1]$$

where r is the rate of discount. P_0 can be interpreted as the value that would be lost if this asset where destroyed at t = 0, or as the present value of the "without project" option when evaluating some proposal to modify the environmental asset and its subsequent time-stream of services.

Individual valuations, $V_i(t)$ -- which are summed, unweighted, across all affected individuals to calculate V(t) -- emerge from the individual solutions to constrained choice problems.

Suppressing i and t, the individual maximizes utility,

$$U = f(Z) \qquad [2]$$

where Z is a vector of activities that yield satisfaction.

The concept of activity is broadly defined, and includes work and other income-generating activities, formal educational activities, reading and watching television and movies (which may have an educational or informational component), eating, household maintenance, hobbies, and recreational activities (including sports, physical exercise, hiking, nature study, sightseeing, etc.).

These activities are produced by the household, in a process which combines purchased good and services, environmental amenities and other public good, and the household's time effort. This production process is governed by the household's activity production technology.

A household production function for activities using a natural resource amenity is represented as:[4]

$$Z = g(X, Q \mid T) \qquad [3]$$

where

X = a vector of goods and services other than the specific natural resource Q; and

T = the household's production technology.

By minimizing expenditures, PX (where P is a vector of prices for commodities X), subject to (i) $U = f(Z) \geq U^O$, the level of satisfaction enjoyed when Q is at its initial level Q^O and (ii) the activity production function (3), one obtains the expenditure function $E^O(P, Q, U^O)$. The first derivative of the expenditure function with respect to Q yields an inverse compensated demand function for Q:

$$\frac{dE^O}{dQ} = -E_q^O(P, Q, U^O). \qquad [4]$$

[4]In this formulation, the household.s time contributed to producing activities is not explicitly introduced, because we make no subsequent use of that variable. In analyses performed for other purposed, (e.g., study of the work-leisure choice), this time variable is often a major focus.

The total value of Q^O to the individual is

$$V = -\int_0^{Q^O} E_q^O(P, Q, U^O) dQ. \qquad [5]$$

Aggregating V across individuals at each time, discounting, and integrating across time, the total value of the environmental asset (1) is obtained.

Several complications are implicit in this formulation of environmental asset values. First, current values V(O) are only a minor portion of the time-stream of values V(t); the remaining values will accrue in the future only. Thus, $V(t)_0$ is the present anticipation of V(t). New information will be introduced at various times, causing anticipations to change. This phenomenon is accepted in asset-pricing theory, where the "efficient markets hypothesis" posits that, at any time, the price of an asset reflects all of the information currently available to market participants. For non-marketed environmental assets, however, the decentralized generation and processing of information envisioned in the "efficient markets hypothesis" is absent. Special efforts are necessary to ensure that $V(t)_0$ incorporates adequate intelligence about future demand and supply conditions that affect Q(t). Alternatively, analysts could pay more attention to gathering and processing information about citizens' current expectations of future environmental services values.

Second, neither the utility function (equation [2]) nor the activity production function (equation [3]) places any prior restrictions on the kinds of activities that may generate utility and value. These include current observable on-site use values, where Q is combined with purchased commodities such as travel, accommodation, and complementary equipment; most economists focused initially on these sources of value. However, total value may also include off-site or vicarious uses, the anticipation of future use, and the value obtained from the simple knowledge that the asset continues to exist.

Third, the activity production function depends on the household's activity production technology, which is subject to augmentation or degeneration over time. The activity production technology at any given time is a function of the activities produced at previous time. Thus, it may be represented as:

$$T_t = h[Z_\tau(X_\tau, Q_\tau \mid T_\tau)]$$

$$\text{for all } \tau \text{ in } 0 \leq \tau < t. \qquad [6]$$

This explicitly recognizes the development of skill in activity production through conscious acquisition of information and instruction and through the less deliberate process of "learning by doing." Past activity production influences the capacity to achieve satisfaction from current activities. Given the nature of the processes by which activity production technology is acquired, it is immediately clear that T may differ

substantially across households, as well as over time in a given household.[5]

A clearer understanding of how technology is developed may clarify the relationships between on-site or "hands-on" use, vicarious use, and enjoyment that depends only on the existence of the environmental asset.

Components of Total Value

The total value of an environmental asset may be defined as in equations [1-5]. In the absence of well-functioning markets for environmental assets, contingent valuation seems to be the only feasible method for estimating total value in a one-shot analysis.

An alternative approach is to attempt a taxonomy of the components of total value, estimate each component using appropriate methods, and sum the component values to determine total value. If the taxonomy is complete and internally consistent, and if estimation methods exist that are appropriate for each of the value components, this approach would permit accurate estimation of total value. It would have the advantage of reducing reliance on a single valuation technique (contingent valuation) because some components of total value are amenable to estimation with other kinds of methods. For some components of total value, cross-technique comparisons may provide evidence about the quality of benefit estimates.

However, the better-known taxonomies of value components were not developed from the outset with systematization in mind. For example, initial successes in establishing the reputability of the travel cost method of valuing on-site recreational uses led some to wonder whether there might be other kinds of value -- vicarious use value, option value, existence value, and/or preservation value -- that were being ignored. Various additional categories of value were proposed and soon the literature was awash in controversy as to whether particular categories of value were scientific (in the sense that they were subject to the rules of evidence common to scientific endeavor) and whether the various categories of value that had been proposed were mutually exclusive. Was it possible, or likely that some of the proposed categories of benefits, when carefully defined so as to avoid double-counting, could be of zero or negative value?

By now, we have reached a stage where relatively complete taxonomies of value components have been proposed, and considerable progress has been made in clearing up controversies about the mutual exclusivity of value components and the possibility that some components may take negative values. The following taxonomy is reasonable representative of the current state-of-the-art.

[5]Stigler and Becker (1977) have argued that the concept of activity production technology is of great potential fruitfulness in explaining differences in activity choice among households. If, as they claim, T is analytically more tractable than the process of preference formation, an appropriate research strategy would focus on T while essentially ignoring tastes and preferences.

Use Value

In general, any activity produced in a process such as that defined in equation (3), in which Q is combined with one or more elements of the X vector, may generate use values. Where Q and some element, X_j, of the X vector are weak complements in production of a particular activity, it is in principle possible to estimate the use values associated with that activity by analyzing data generated by transactions in the market for X_j. The weak complementarity approach has been useful in evaluating benefits generated by on-site use. Weak complementarity between travel services and destination site quality provides the basis for the travel cost method of valuing recreation amenities, while use values for location-specific amenities are often estimated by analyzing the housing and labor markets. For these cases, the researcher is not confined to contingent valuation methods which allows those who prefer other kinds of methods to use them.

On-site recreation benefits and the value of amenities associated with places of residence and work are only a few of the use values generated by environmental assets. Others include incidental use, such as viewing scenery while traveling for a different purpose; off-site use such as looking at pictures, descriptions and accounts made available through various media; and non-participant or vicarious uses, such as another person's environment-related activity. Although these kinds of on-site uses are important, they do not readily generate information about participation rates or user values.

In summary, those applications of the weak complementarity approach that are commonplace are nevertheless confined to a mere subset of use values.

It is necessary to distinguish among four classes of use values, on the basis of the timing of the use decision (past or future), the uncertainty that attaches to future use, and the value that attaches to delaying irreversible decisions about use if new information is expected to become available later.

Past and Current Use Values are observable ex post (i.e., after the use decision has been made). For certain kinds of use (including several that are frequently researched), ex post use is routinely recorded and amenable to valuation methods founded upon the assumption of weak complementarity.

Expected Value of Future Use.--Future use is ex ante (i.e., the irrevocable use decision is yet to be made), uncertain, and subject to change as new information becomes available. Future use must be projected from past use or inferred from, for example, survey data stating the ex ante intentions of the identifiable user population. The expected value of future use -- often called "expected surplus" -- may be projected from studies (including those that apply weak complementarity techniques) of ex post use values, or estimated in CVM studies of ex ante use. In another article in this report, Smith points out that the welfare analytics of ex post and ex ante use value are fundamentally different, and these differences should lead to different empirical estimates (or, more precisely, empirical estimates of different constructs). Applied procedures that estimate the stream of future benefits generated by an envi-

ronmental resource (a fundamentally ex ante concept) by adding ex post and ex ante estimates of various components of value, therefore, are internally inconsistent.

(Ordinary) Option Value.--If uncertainty attaches to the future availability of the environmental asset, a risk-averse household may be willing to pay a premium beyond expected surplus (ES) to ensure future availability. This premium has been called "option value" (OV). However, the total willingness to pay, now, for an option for future use is called "option price" (OP), defined so that OP = ES + OV. There has been considerable controversy (Schmalensee 1972) as to whether OV may take a negative value, in contrast to the positive value assumed by early writers such as Weisbrod (1964). The problem is that there are two kinds of risk: demand risk, in which a purchased option would prove useless if future demand did not eventuate; and supply risk, in which future availability is not assured unless the option is purchased. In buying an option, one may encounter demand risk as a result of an act taken to avoid supply risk. Only in the case where demand is certain and supply uncertain can we be assured that, for a risk averse household, OV > O and OP > ES (Bishop 1982).

These constructs (ES, OV and OP) are all based on the notion of sure payments. Building upon the literature on the economics of insurance, Graham (1981) has shown that some schemes of ex post contingent payments may generate values greater than the larger of OP and ES. Graham defines the "fair bet point" (FB), which always has an expected value equal to or greater than OP.

It seems clear that FB is the ideal construct for valuing future use under uncertainty. OP can be viewed as the second-best construct, because it is the value that emerges in the absence of perfect contingent claims markets.

Neither FB nor OP is directly observable. Both could be estimated via CVM; but, the complex notion of contingent claims markets that is fundamental to FB might not be effectively communicated to CVM respondents. This suggests a pragmatic emphasis on estimating OP via CVM, at least until experiments in estimating FB via CVM have been reported.

A second-best approach is to project ES from ex post use data, perhaps from analyses using weak complementarity approaches, and estimate OV in a separate exercise. OV can presumably be estimated only via CVM. Freeman (1984) suggests that OV usually will be quite small. If so, a third (and yet less desirable) approach is merely to estimate ES and use it as an approximation of future use values. Note that these second and third approaches incorporate the error (discussed in Smith's article in this volume) of confusing and/or admixing ex ante and ex post value constructs.

Quasi-Option Value.--Arrow and Fisher (1974) and Henry (1974) introduced the concept of quasi-option value, which has special pertinence to preservation vs. development decisions. If development is irreversible (e.g., preservation in period 1 allows the choice of preservation or development in period 2, but development in period 1 pre-ordains development in period 2) and new information about the value of preservation is likely to emerge after period 1 but before the period 2 decision must be made, quasi-option value is positive. It is, essentially, the value of the emerging information conditional on having made the period 1 choice (preservation, in this case) that maximizes the period 2 array of alternatives (Hanemann and Fisher 1984).

The literature does not include empirical estimates of quasi-option value; but Hanemann and Fisher (1984) provide some numerical examples that suggest that quasi-option value may be quite large (and incidentally, much larger than ordinary option value) where preservation is an alternative to irreversible development.

The distinction between ordinary option value and quasi-option value has been the subject of considerable confusion in the literature. The Appendix of this paper offers one more attempt to clarify these concepts.

Existence Value

Value may be generated simply by knowing that the environmental asset exists. Use value is defined as any value that emerges from activities produced by combining Q and any element of X. Existence value must be generated by activities produced by the process

$$Z = g(O, Q \mid T) \qquad [7]$$

which is a special case, in which X = O, of the process in equation [3]. That is, existence values for Q are generated by Q alone, subject to an activity production technology (T) which permits an understanding and appreciation of Q. No elements of the X vector are involved in the current time period. However, activities combining Q and X in some previous time periods seem essential to the acquisition of the kinds of T which permit existence activities (eq. [6]).

Pure existence value excludes any values that arise from current use or anticipated future use. Because vicarious consumption is a kind of use, all pure existence demands must be altruistically motivated. One can conceive of "interpersonal altruism" which would generate existence values from knowing Q was available for others to use; "intergenerational altruism" from knowing Q will be available for future generations; and "Q-altruism," in which the household enjoys the feeling that Q itself is benefiting from being undisturbed. The last two kinds of altruism generate "bequest values" and "intrinsic values," respectively, which are categories of existence value. Note that this discussion of various altruistic motives for existence value is not predicated on any assumption that different motivations have different observable consequences. Rather, it is intended merely to point out that there are several common human motivations that could lead to positive existence values.

Randall and Stoll (1983) offered some observations about the nature of existence value. Existence services have most all of the characteristics of other economic goods except ready

marketability. One can conceptualize a demand for, and a supply of, existence. Existence is best treated not as a discrete phenomenon (it exists or it does not), but as a continuous phenomenon (there exists more or less of some particular Q). Because supply and demand may well be continuous functions, it makes sense to distinguish between total existence value and existence value at the margin.

It follows that many kinds of goods and services have potentially significant existence values, at least in total. For commonplace goods and services, proposed projects seldom significantly reduce the supply of existence and, thus, threaten only trivial losses in existence value. Existence values are not confined to unique environmental amenities threatened with irreversible destruction. For that matter, existence values are not confined to environmental amenities at all. They occur for human artifacts and cultural manifestations, (e.g., historic buildings, grand opera, and Navajo rug weaving). Uniqueness and the threat of irreversible loss, however, are circumstances in which the incremental loss of existence values are likely to be greatest.

Existence is not only a global phenomenon. It is perfectly reasonable that the extirpation of some environmental or cultural asset from a local region would cause locally important losses of existence value, and may even be lamented in distant places.

Existence value, by definition, must be generated in processes that use Q, but not in combination with any element of the X vector, subject to an activity production technology. Nevertheless, it seems that some kind of past use is not only permissible but strictly necessary to the generation of significant existence values. Without some kind of past use, how could the technologies that permit knowledge, understanding, and appreciation of Q arise?

As environmental assets are discovered and used, through either on-site or "hands on" experiences or exposure to descriptions, representations or accounts, the technology relevant to existence activities is likely to be augmented. Existence demands, therefore, would be expected to increase for some time following discovery. This would not always be true of existence value at the margin, because there are conceivable cases in which use experiences would shift perceived existence supply sharply rightward, as what was once newly discovered comes to be recognized a commonplace.

In addition to activity production technology, the role of information about existence supply seems crucial to the determination of marginal existence values.

The processes of discovery and learning, as new information becomes available and activity production technologies are augmented, introduce a substantial volatility into total and marginal existence values. Randall and Stoll (1983) discuss the case of the snail darter. Until its discovery in 1973, its existence demand was zero. Its existence demand rose rapidly as it was accepted as a separate species and listed as endangered, and as knowledge of its existence and its plight spread rapidly among the public. Given its limited supply, it acquired a substantial marginal existence value. More recently, snail darter populations have been found in some streams where they were previously unknown, shifting the perceived supply to the right and, presumably, reducing the existence value of the marginal snail darter. It is important to realize that this volatility of existence value has nothing to do with measurement error or bias. It is not that "the estimates" are volatile; the problem is that the perceived reality of existence value is volatile, especially when relatively large amounts of new information may be added to a small initial information base.

It is readily apparent that, of the established techniques of non-market valuation, only CVM offers any hope of estimating existence value.

Approaches To Estimating Total Value

The "taxonomy of components" approach would suggest that total value should be determined by summing the results of independently estimated current use values for all uses, option price, quasi-option value (if relevant), and existence value. Estimation methods based on weak complementarity or hedonic price theory are obvious candidates for estimating the values that emerge from those kinds of uses that are on-site and require travel or are location-specific to the place of residence or work. Further, these kinds of methods may permit projection of expected surplus from future use, which may be a serviceable approximation of option price, itself perhaps a serviceable approximation of the "fair bet point." For all other components of total value, it seems that the broad class of contingent valuation methods offer the only present real hope of value estimation. These value components include many kinds of use values, in addition to the more obvious cases of option price (or option value if expected surplus is otherwise estimated) and existence value. Corroboration of CVM value estimates with estimates obtained using other methods is infeasible in these cases. Further, for many of these cases, there seems little hope of obtaining independently-generated evidence that these values are real and positive.

An alternative approach is to attempt one-shot estimation of total value via CVM. It is relatively simple to convey the notion of total value to a CVM participant, pointing out that all current use values (including the informal, off-site, and vicarious), future use values and existence values are to be considered. However, there seems to be much subtlety inherent in any taxonomy of value components. The distinction between vicarious use value and existence value, and the precise definition of option value would seem to place considerable responsibilities of communication upon the designer of a CVM exercise, the interviewer or experimenter, and the citizen participant.

The following, more elaborate, approach may serve to enhance credibility of benefit estimates among the widest possible audience. Estimate total value via CVM. Where major categories of current use value are amenable to estimation via weak complementarity and hedonic price theory approaches, and the resulting estimates can be used to project

future use values, these approaches should also be implemented. Two kinds of corroboration would then be possible. These same categories of value could also be estimated via CVM, allowing direct tests of comparability. As long as the CVM estimate of total value exceeds the estimates (obtained by any and all methods) of major categories of current and future use value, the CVM estimate of total value can be taken as a lower bound on total value. This follows from two observations: (1) important positive components of value are included in one-shot total value but not in the estimates of specific categories of use values; and (2) CVM formats can be designed that seem to be immune to overestimating total value.

Is CVM a Satisfactory Benefit Estimator?

Estimation of total value will require considerable reliance on contingent valuation. Avoidance of CVM seems certain to result in the omission of important components of total value. For this reason, it is important to summarize here some recent results pertaining to the satisfactoriness of CVM as a benefit estimator (Hoehn and Randall 1987).

The issue with CVM has always been data quality. If the value data can be trusted, these data (unlike the data used in weak complementarity and hedonic price theory approaches) can be directly interpreted as theoretically valid estimates of welfare change (Bradford 1970, Randall et al. 1974, and Brookshire et al. 1980). However, CVM data are self-reported by participants in interaction with a researcher or his representatives. One concern is that various self-reporting biases, and other biases inadvertently introduced by the research design and/or the interaction between researcher and participant, may be endemic to CVM. However, much empirical evidence supports CVM, despite occasional anomalous results. The general perception among environmental economists may be summarized by the following quotation from an author who was once himself among those skeptical of CVM.

> "(T) here is growing recognition that contingent valuation is turning out better than many people, including the present writer, expected... The 'bottom line' seems to be that, while contingent values are not precise, they are sufficiently accurate to be useful in policy analyses" (Bishop 1984 draft of his article in this report).

Hoehn and Randall (1987) take the attitude that most of the purported biases in contingent valuation are rather simple concerns that can be avoided or minimized through careful attention to research design, sampling, and administration of the experiment or survey. The two concerns that they recognize as genuinely interesting are: (1) individuals may behave strategically, misreporting their "true" valuation in order to influence the outcome of the research; and (2) individuals may treat the whole exercise as hypothetical or inconsequential, and thus devote little effort to the introspection that is necessary to discover what one's "true" valuation really is. Hoehn and Randall analyze these issues by assuming a rational self-seeking respondent and using simple theoretical models to predict his/her behavior when confronted with a CVM exercise.

Assume an individual -- an experimental subject or survey respondent -- believes the results of the valuation exercise will influence policy. Assume also that the individual perceives that she is a member of a sample of citizens participating in the exercise. Does she "take it seriously?" It is reasonable to assume she will take it at least as seriously as voting in elections or participating in a political poll (where, again, her influence is magnified because she is a member of a sample chosen to represent a larger population).

Now, assume that formulating ("figuring out") her WTP/WTA for specified changes in Q (or, even more difficult, specifying her total value curve) is not so simple a task that it can be accomplished instantaneously and without cost. The choices offered in the contingent market seldom are familiar and routine, even with the best research design. There is a positive relationship between the effort she invests in value formulation and the precision of the value at which she arrives. If the value formulation task is very difficult and/or the individual limits the effort she invests therein, she may solve the value formulation problem incompletely or imprecisely.

This places in perspective the difference between contingent markets and "real" markets. First, the goods offered in contingent markets are not always familiar, and individuals may not associate these particular goods with trading possibilities. Unfamiliar goods are often introduced in "real" markets and, especially, in market experiments. So, this distinction between "real" and contingent markets is, if anything, a matter of degree. Second, the penalty for a wrong decision may be substantial in "real" markets; your money is gone and you are left with some purchase that has disappointed you. However, there is a penalty for a wrong decision in a contingent market; one's opportunity to influence policy is wasted or misused. Again, the distinction between "real" and contingent markets is, if anything, a matter of degree.

If value formulation is imperfect in contingent markets, the formulated values would include some error. If valuation is performed in the Hicksian compensating framework (i.e., WTP for increments in Q and WTA for decrements), imperfect value formulation would lead to understatement of WTP and overstatement of WTA.[6] At least, we know the direction

[6]The intuitive explanation of this result is as follows. In order to formulate her WTP, the participant must first solve the problem: minimize expenditure subject to utility constrained at the initial level. Imperfect solution of that problem can have only one kind of outcome, the identification of some expenditure larger than the minimum. This overestimation of minimum expenditure must lead the participant to underestimate her compensating surplus, WTP. Thus, any error in formulating WTP in a compensating framework would lead to its understatement.

If equivalent measures of value are sought, the results of formulation error are not so clear. There are two problems to solve: (1) the "with policy" or subsequent, utility level must be found by maximizing utility given the subsequent opportunity set; and (2) expenditure must be minimized subject to utility constrained at the subsequent level. Formulation error at stage (1) would, again overstate expenditure. The final outcome is ambiguous when equivalent measures of value are used.

of any error that incomplete value formulation would introduce; the directional effect is to understate the value of gains and overstate the value of losses. This kind of error has a conservative influence on BCA.

Now, assume the individual is not above strategic behavior, defined as reporting something other than one's formulated value in order to influence the results of the exercise in one's favor. Some participants would reject this kind of behavior on moral grounds, while others would recognize that strategic behavior is itself resource-consuming and decide not to use resources that way. Nevertheless, it is prudent to consider what kind of effect those who choose to attempt a strategic response might have on reported contingent valuation results.

To identify optimal strategies for participants, first specify the incentives that they face. For simplicity, assume that U = U(Q,Y), where Y is a numeraire consisting of "all other goods." Assume the individual gains positive utility from both Q and Y. In other words, she likes Q and does not like taxes or payments that would reduce her disposable income for purchasing other goods. The key issue, then, is how her participation in the exercise is likely to influence (1) the chances that a policy to increase Q will be implemented and (2) her disposable income, if the policy is enacted. One can model a variety of alternative contingent markets, to examine how their structure affects these things. Here, some of these models for WTP are outlined; the arguments are analogous for WTA, where the effects are usually similar but of opposite sign.

1. The government will provide the increment in Q without regard to the outcome of the benefit cost analysis. The researcher will collect stated WTP from each participant at the end of the exercise. However, Q is nonexclusive and participants will enjoy the increment in Q regardless of their reported (and paid) WTP. Strategizing respondents would report zero or very low values for WTP.

2. The government will provide the increment in Q if and only if the estimated benefits for the affected population exceed the costs. The researcher never collects the stated WTP, and nor does anyone else. The participant is forever immune from bearing any of the costs. Strategizing respondents would state high values for WTP in order to increase the probability of implementing the policy.

   These cases can be dismissed immediately, because they are quite false representations of the policy environment. Case (1) is of some interest, in experimental economics, as the case most likely to elicit free-ride behavior. However, it is not common policy practice to implement proposals independently of benefits and costs, and to finance them through contributions determined by self-reported WTP. Case (2) has some appeal on the surface, because in CVM practice, the researcher seldom collects WTP. However, a deeper analysis suggests that participants realize that if the exercise is to affect policy they will eventually pay (usually through some combination of user fees, higher taxes, and higher prices) for increments in Q. The assumption that the participant is forever immune from contributing toward the costs of policy is untenable.

More relevant models of the incentives influencing behavior in contingent markets include the following cases.

3. The proposal is implemented if the estimated benefits exceed the costs; and citizens pay in proportion to stated WTP.

4. The proposal is implemented if the estimated benefits exceed the costs; and citizens pay their per capita share of the costs.

5. The proposal is implemented if a majority of citizens approves it, given that each pays her per capita share of the costs.

In each case, the participant who likes Q but dislikes bearing additional expenses must devise a strategy designed to increase the expectation that the policy is implemented, but at the least cost to her.

Optimal reporting strategies are, for cases (3) through (5):

3. Report WTP equal to or less than one's formulated WTP. Optimal reporting strategy is related to sample size. Generally, it is best to report WTP approaching one's formulated WTP, if one believes the sample is small; with very large samples, the tendency toward free-riding is stronger.

4. If one suspects one's formulated WTP is quite different to that of other citizens, exaggerate the difference so as to shift the sample mean reported WTP nearer to one's own formulated WTP. If one expects one's WTP is a little higher than the mean, report a value still higher; similarly, if one's WTP is likely to be lower than the mean, report a value still lower.

5. No strategy is individually preferred to truth-telling. If the stated per capita cost is lower than one's WTP, it is optimal to report approval; if one' WTP is lower than the stated cost, it is individually optimal to report disapproval.

In case (3), there would be a tendency to underestimate benefits. In case (4), the variance of individual WTP would be increased, widening the confidence interval around estimated benefits. If reported WTP is limited to a minimum of zero but has no upper limit, mean reported WTP might be biased upward. However, there are statistical methods for dealing with this problem. If these methods are used, total estimated benefits would be unaffected by reporting strategies.

In case (5), there is no reporting bias. Note that, in this case, the results are expressed in terms of "number of participants expressing approval/disapproval of the proposal given a per

capita cost of $___." These results are not immediately interpreted as WTP. All we know is that those who approve have formulated a WTP greater than the stated cost, while those who disapprove have formulated a WTP less than the cost. Nevertheless, if (1) the sample is divided and different subsamples respond to different stated costs and (2) the data are analyzed with appropriate statistical tools (e.g., logit analysis), valid benefit estimates can be obtained. An alternative approach is to repeat the "approve/disapprove" question with the same participant, stating different levels of per capita cost. In that way, the researcher could iteratively approach the participant's indifference point, while retaining the desired anti-strategic properties of the "majority vote" format.

This conceptual analysis of the participant's likely behavior in a contingent valuation exercise, in formulating and reporting her responses, has several implications which appear to have been corroborated in empirical applications.

First, while the incentive for careful decisionmaking and truthful reporting of valuation are not as strong as in private goods markets, they are not absent in contingent valuation exercises. This suggests that carefully designed contingent valuation studies will collect a substantial body of serviceable value data, perhaps along with a minority of less reliable observations.

Second, for a fairly wide range of contingent market designs, any biases introduced in formulating and/or reporting WTP are likely to have the effect of understating it. This applies to contingent markets based on Hicksian compensating measures of value, and assumes use of appropriate statistical analyses. Following Hoehn and Randall (1987) a "satisfactory benefit cost estimator" can be defined as one that correctly identifies all proposals that would not generate a potential Pareto-improvement (PPI) while correctly identifying at least a subset of those that would bring about PPIs. It follows that any BC estimator that reliably reports WTP, (i.e. benefit), estimates no greater than their "true" values is satisfactory. Thus, a considerable class of CVM formats that are satisfactory BC estimators can be identified.

Third, contingent valuation formats vary, and their performance characteristics differ in ways that are, to some extent, predictable. Thus, the quality of contingent value data can be improved with careful attention to contingent market design. Use of Hicksian compensating value measures and referendum formats, as in case (e), are obvious ways to minimize bias in estimated benefits while ensuring that any remaining bias is toward understatement.

These recent results have important implications for the total value dilemma. The one-shot approach to total valuation relies entirely on contingent valuation. The "taxonomy of components" approach arose historically because attractive non-CVM valuation methods were developed for specific kinds of current and future use values. The "taxonomy of components" approach allows the use of these non-CVM methods where appropriate, while attempting to plug the holes and fill the gaps with CVM studies. Without some considerable reliance on CVM, total value estimation must remain inaccessible. Further, given the disadvantages of the "taxonomy of components" approach, those who favor it must presumably believe that the opportunities it provides for estimating some value components without recourse to CVM is an offsetting advantage. Thus, any new information with respect to the reliability or satisfactoriness of CVM has important implications for the feasibility of total value estimation and the choice of approach to be taken.

Possibility of Market Corroboration for Existence and Vicarious-Use Values

The likely empirical dominance of off-site use values and existence values in the total values associated with certain well-known and unusual environmental assets creates a special urgency about establishing the contributions of these components to total value. Because of some skepticism about contingent valuation, it would be useful to develop non-CVM methods of estimating off-site use and existence values, or of independently corroborating that such values are real, positive, and substantial (Schulze et al. 1981).

Two suggestions are offered here, addressed to existence value and the kinds of off-site use values that are generated when one enjoys environmental amenities via pictures, description and accounts made available through various communications media.

In the case of existence value, the possibility of third-party observable corroborating evidence is massively diminished by the definition of existence value as those values derivable from Q when every element of the X vector is held to zero. Nevertheless, the concept of activity production technology offers some hope. Such technology must be acquired only through past use, on-site and/or off-site. Further, individuals make conscious choices as to how much they invest in the acquisition of these technologies. Some technology may be acquired passively, as a result of incidental exposure rather than conscious effort. Nevertheless, the conscious investment of effort and resources in order to acquire activity production technologies frequently may be observed. Evidence of technology could be systematically documented with some research effort. It seems reasonable that existence demands do not diminish as production technologies for existence activities are augmented. Thus, systematic evidence of technology acquisition would provide third-party verifiable evidence of positive existence values. Evidence that technology acquisition was increasing over time, similarly, would provide evidence that existence values were increasing with the passage of time.

Second, those off-site use values that rise from the enjoyment of environmental amenities via pictures, descriptions and accounts made available through the communications media are of interest per se, and because this kind of use is likely to be important in the acquisition and augmentation of existence activity production technologies. Even casual examination of the communications media suggests the very

substantial allocation of effort to describing and depicting environmental assets, both for their own sake and as essential background to various narratives, etc.

There is no inherent reason why the economics of the communications media ought to be intractable. It should be possible to estimate demands for books, magazines, films, television programs, etc., in general and to partition out the demands for articles and programs with a strong focus on particular environmental assets. There is no good reason to believe that these demands would be other than downward sloping, which suggests that the consumer's surplus enjoyed by their audience would be positive and measurable. The existence of copyright and similar laws, however, suggests that not all of the economic surplus associated with these communications is enjoyed by consumers; some of it, apparently, any be appropriated by authors, photographers, publishers, and the like. Usually, it is assumed, the subject matter has no legal rights, and is unable to extract rents. More and more commonly, however, people who have been able -- on account of their charisma, positions of power and influence, participation in activities thought exciting, or even entirely fortuitous roles as participants or bystanders at some spectacular event -- to acquire celebrity or notoriety, have extracted rents from the communications media by selling rights to their stories, interviews, etc. It is by no means idle to wonder what revenues -- given institutions that would permit it -- the "trustees" of the Grand Canyon could accrue by licensing all media representations thereof.

More formally, it ought to be possible to estimate the necessary economic relationships and calculate the economic surplus attributable to the environmental asset subject matter of these various media presentations. If there are important and policy-relevant environmental assets for which on-site use values are but a small proportion of total value, then investment in at least a few prototypical research studies of this kind is warranted.

References

Arrow, K.J., and A.C. Fisher. 1974. Environmental Preservation, Uncertainty, and Irreversibility. Quarterly Journal of Economics, 55(2):313-319.

Bishop, R.C. 1982. Option Value: An Exposition and Extension. Land Economics, 58(1):1-15.

Bradford, D.F. 1970. Benefit-Cost Analysis and the Demand for Public Goods. Kyklos, p. 775-791.

Brookshire, D.S., A. Randall, and J.R. Stoll. 1980. Valuing Increments and Decrements in Natural Resource Service Flows. American Journal of Agricultural Economics, 62:478-488.

Cummings, R.G., D.S. Brookshire, and W.D. Schulze (with contributions and comments by others). 1986. Valuing Environmental Goods: A State of the Art Assessment of the Contingent Valuation Method. Totowa, N.J.: Rowman and Allenheld.

Freeman, A.M. 1984. The Sign and Size of Option Value. Land Economics, 60:1-13.

Graham, D.A. 1981. Cost Benefit Analysis Under Uncertainty. American Economic Review, 71(3):715-725.

Hanemann, W.M. and A.C. Fisher. 1984. Option Value and the Extinction of Species. Presented to the annual meeting of the Association of Environmental and Resource Economist, Dallas, Texas, December 28-31.

Henry, C. 1974. Option Values in the Economics of Irreplaceable Resources. Review of Economic Studies: Symposium on the Economics of Exhaustible Resources, p. 89-104.

Hoehn, J.P., and A. Randall. (1987): A Satisfactory Benefit Cost Indicator from Contingent Valuation. Journal of Environmental Economics and Management, 14:226-247.

Randall, A., J.P. Hoehn, and D.S. Brookshire. 1983. Contingent Valuation Surveys for Evaluating Environmental Assets. Natural Resources Journal, 23:635-648.

Randall, A., and B. Ives, and C. Eastman. 1974. Bidding Games for Valuation of Aesthetic Environmental Improvements. Journal of Environmental Economics and Management, 1:132-149.

Randall, A., and J.R. Stoll. 1983. Existence Value in a Total Valuation Framework. p. 265-274. *In:* R.D. Rowe and L.G. Chestnut, editors, Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas, Boulder: Westview Press.

Schmalensee, R. 1972. Option Demand and Consumer's Surplus: Valuing Price Changes Under Uncertainty. American Economic Review, 62(5):813-824.

Schulze, W.D., D.S. Brookshire, and M.A. Thayer. 1981. National Parks and Beauty: A Test of Existence Values. Paper presented at the American Economic Association Annual Meeting, Washington, D.C.

Stigler, G.J. and G.S. Becker. 1977. De Gustibus Non Est Dsputandum. American Economic Review, 67(3):76-90.

Weisbrod, B.A. 1964. Collective-Consumption Goods. Quarterly Journal of Economics, 78(3):471-477.

APPENDIX: THE DISTINCTION BETWEEN (ORDINARY) OPTION VALUE AND QUASI-OPTION VALUE

Since Henry (1974), there has been some conceptual confusion about option value and quasi-option value. The appendix attempts to clarify these concepts by constructing a well-specified problem-context and showing how option value and quasi-option value can be defined in this common context.

The Problem Context

Consider an environment that may at any time t be in either of two mutually exclusive states, preserved ($p_t = 1$) or developed ($p_t = 0$). At the outset, $p_1 = 1$, but development, should it ever occur, is irreversible. Thus $p_t = 0, 1$ and $p_{t+1} \leq p_t$.

Let $\theta_t = 1$ if the state $p_t = 1$ is demanded at time t; and $\theta_t = 0$, otherwise. At some earlier time τ, demand at t may be uncertain and there is some expectation $(0 \leq E(\theta_t^\tau) \leq 1)$ that $p_t = 1$ will be demanded. Similarly, $\phi_t = 1$ if preservation is supplied at time t, and 0 otherwise. Of course, preservation may be supplied at time t but not chosen; that is, $\phi_t = 1$ permits but does not require $p_t = 1$. Given that the choice of $p_{t-1} = 1$ guarantees $\phi_t = 1$, the chooser can (by her decision with respect p_{t-1}) determine θ_t. However, future supply may be uncertain for those who are not in a position to choose the value of p in preceding periods. For them, the expectation θ_t^τ may take values:

$$(0 \leq E(\phi_t^\tau) \leq 1).$$

Subsequent analysis is simplified by restricting t to the values 1, 2.

Quasi-Option Value

In period 1, the individual does not know the magnitude of θ_2, but she does know that she will know θ_2 when the time comes to choose the second-period allocation. That is, θ_2^1 is uncertain but θ_2^2 is known. In determining her willingness to pay (WTP) for the state $p_1 = 1$, is there a positive component that is attributable to the prospect that θ^2 will be known? In other words, is $p_1 = 1$ worth any more if θ_2^2 is known than if $\theta_2^2 = \theta_2^1$ and is uncertain?

The answer is "yes." The increment in value is called quasi-option value (Arrow and Fisher 1974) and has been shown (Hanemann and Fisher 1984) to be equal to the value of information about θ_2^2 conditional on $p_1 = 1$ having been chosen.

(Ordinary) Option Value

While θ_2^1 is uncertain, so is θ_2^2; $E(\theta_2^1) = E(\theta_2^2) \leq 1$ and nothing is learned about future demand as time passes. The period 2 use decision must be made when θ_2^2 remains uncertain. Nevertheless, an uncertain demander may be willing to pay some premium for $p_1 = 1$ because the choice of $p_1 = 1$ guarantees $\phi_2^1 = 1$. That is, the choice of $p_1 = 1$ provides an option for $p_2 = 1$; or, to put it yet another way, increases and secures supply from $0 \leq E(\phi_2^1) \leq 1$ to $\phi_2^1 = 1$. What is the value of the premium?

This problem is usually addressed by assuming risk aversion. However, there are two kinds of risk. If the individual does not buy the state $p_1 = 1$, by her default ϕ_2^1 remains uncertain; i.e., there is a supply risk. In addition, the individual faces a demand risk, in that a loss would be suffered in the event $E(\theta_2^1) > 0$ and she paid a premium for $p_1 = 1$ to ensure $\phi_2 = 1$, only to discover (later) that $\theta_2 = 0$ and $p_2 = 1$ is not demanded. For a risk averse person, supply risk would elicit a positive premium while a negative premium would be associated with demand risk.

The mainstream literature is summarized by Bishop (1982), who concludes that, in simple formulations of this problem, the net premium is non-negative when $\theta_2^1 = \theta_2^2 = 1$. If demand is uncertain, as well as supply, general statements about the sign of the net premium are elusive. The net premium is called option value (OV). The conventional wisdom is that option price (OP), which represents the future use value of $p_2 = 1$ plus the risk premium (or discount) for $\phi_2^1 = 1$ is the correct value at $t = 1$ for the state $p_2 = 1$. However, it is appropriate to remind the reader of the reservations expressed by Graham (1981) and Smith (1985 manuscript) and discussed in the text of the present paper.

The "With and Without Principle"

Bishop (this volume) argues that quasi-option value is "nothing special," in the sense that -- if the emergence of new information is predictable -- its conditional value would be attributed to the $p_1 = 1$ alternative in the normal course of applying the venerable "with and without principle" of benefit cost analysis.

The "nothing special" argument seems applicable also to (ordinary) option value. The consequences of risk aversion, where it exists, should ordinarily be incorporated in BCA in the normal course of applying the "with and without principle."

Nevertheless, the concepts of quasi-option value and option value -- even if they are merely specialized application of the "with and without principle" -- serve the useful purpose of drawing attention to certain requirements of ex ante benefit evaluation that might otherwise be overlooked.

Is a More General Analysis of Ex Ante Benefits Under Uncertainty Feasible?

A general ex ante evaluation of benefits under uncertainty requires that risk aversion be considered along with the prospects for emergence of new information about demand, and that the analysis be generalized by dropping the restrictions that p, θ, and ϕ are binary variables and permitting $p_{t+1} > p_t$ at some finite cost of restoring the preserved state.

However, the special-case problems have been solved because they can be formulated as simple mathematical puzzles soluble with Jensen's inequality (quasi-option value) and simple concavity notions of risk aversion (ordinary option demand). Solution of the general problem, when formulated, will be a more challenging undertaking. Progress is likely to

come in "nibbles," as less restrictive versions of various special cases are solved.

Again, we are brought back to the total value dilemma. Ex ante total value of benefits is logically coherent and empirically accessible by CVM. The "taxonomy of value components" approach allows non-CVM methods of estimating ex post benefits of certain uses, but at the cost of persistent internal inconsistency in the taxonomy of value components itself.

Existence Values and Normative Economics

David S. Brookshire, Larry S. Eubanks, and Cindy F. Sorg[1]

Abstract.--This paper reviews the various definitions of existence value found in the literature and discusses several issues that are important in clarifying what is meant by existence value. In addition, it is suggested that individuals may express a willingness to pay to preserve nature which may not in all cases be interpreted strictly as an economic benefit.

Resource valuation has evolved dramatically. The methods have improved and the range of resources to be valued and types of values have been expanded. Values have been assigned to wildlife, visibility, health effects and many other resources. The increasing recognition of a larger array of appropriate benefits (such as use, option, existence values) also has greatly expanded the possible applications of benefit-cost analysis.

The question as to what constitutes the appropriate range of types of benefits for use in evaluating decisions involving alternative use of natural environments must be addressed. Now a dollar benefit can be assigned to an array of commodities without the rules of defensibility being well defined. Further, given the ability to assign dollar benefits to natural phenomenon for use in a traditional benefit-cost framework, is the nature of the values in conflict with the normative basis of the benefit-cost framework? It may be given the progress in expanding the versatility of benefit estimation for types of values previously considered unquantifiable. Taken to the extreme, benefit-cost analysis potentially could be utilized to "justify" any proposal.

Consider the question, "What is species X worth?" The economist following disciplinary definitions of value approaches the problem from the perspective of quantifying a use, or option value. In part, the increased range of types of benefits for a larger array of natural phenomenon is the result of the development of the contingent valuation method, which enables monetary quantification of natural assets (Cummings et al. 1986).

[1]Brookshire is Professor of Economics, University of Wyoming. Eubanks is Assistant Professor of Economics and Public Administration, University of Colorado-Colorado Springs. Sorg is Wildlife Biologist, Rocky Mountain Forest and Range Experiment Station. Station headquarters is in Fort Collins, in cooperation with Colorado State University.

Initially, the CVM conceptual development and empirical applications principally focused on the use or participant benefit values. More recently, researchers have considered other suggested elements of value--option, quasi-option, bequest, preservation, altruistic, vicarious, intrinsic and existence values. Significant effort has been directed toward option value relating to strict definitional interpretations, concern for the proper sign and magnitude, and appropriateness within a benefit-cost framework (Weisbrod 1964, Schmalensee 1972, Graham 1981, Bishop 1982, Smith 1983, Freeman 1984, Smith 1985). A consensus is evolving that option values are appropriate for use and are important in decision-making, especially within a benefit-cost framework.

This paper is concerned with other suggested components. First, a consensus does not exist as to what type of preferences are represented by values associated with existence of natural environments. There appear to be definitional differences and overlaps within the literature. For example, intrinsic, bequest, stewardship, and altruistic values and motives all have been suggested interchangeably or collectively to be part of and/or to represent existence value. For use within a policy framework this issue must be resolved.

Second, existence values do not appear to be bounded relative to other values, such as use value. For example, Greenley et al. (1981) found that existence values, broadly defined, for preserving water quality of the South Platte River in Colorado were 53% of use value. In contrast, Brookshire et al.[2] found derived existence values for visibility preservation at the Grand Canyon National Park (which were more narrowly defined) were 61:1 relative to user values. Without some better understanding of the possible dominance of existence values, resource managers will have trouble interpreting re-

[2]Brookshire, D. S., W. D. Schulze and M. D. Thayer, "Unusual Aspects of Valuing a Unique Environmental Asset," Manuscript 1984.

sults of benefit-cost analysis that do or do not include existence values.

Third, given what we later argue existence value to be, all expressions of existence value as willingness to pay measures are not necessarily consistent with the normative basis of benefit-cost analysis. That is, existence values may or may not relate only to the efficiency-based ethic underlying benefit-cost analysis. Thus, inclusions of all monetary representations of existence value in a benefit-cost analysis would be inappropriate.

Sen (1977) distinguishes between sympathy and commitment in asking whether economic models are rich enough to capture behavior that is both maximizing as well as non-maximizing. That is, how is counter-preferential choice, which destroys the traditional assumptions of preference ordering to be viewed? Sympathy characterizes the case in which a concern for others directly affects one's own welfare.

> "When a person's sense of well-being is psychologically dependent on someone else's welfare, it is a case of sympathy; other things given, the awareness of the increase in the welfare of the other person then makes this person directly better off." (Sen 1977)

Clearly, behavior based on sympathy will be self-interested and egotistic. Thus, sympathy represents the notion of externalities. In contrast, commitment represents counter-preferential choice.

> "One way to define commitment is in terms of a person choosing an act that he believes will yield a lower level of personal welfare to him than an alternative that is also available to him." (Sen 1977)

What is critical to this discussion is that the notion of commitment breaks the identity between personal choice and personal welfare as is traditionally assumed. As noted by Sen (1977), the term "preference" is used to capture this identity. If commitment is related to personally-held ethics, then a wedge is driven between personal choice or behavior and personal welfare. "The basic link between choice behavior and welfare achievements in the traditional models is severed as soon as commitment is admitted as an ingredient of choice," (Sen 1977). Thus commitment represents a case where efficiency is not the underlying criterion in making choices.

Given the framework for normative economics, willingness to pay for the existence of a resource need not have the same normative status as a willingness to pay for a traditional private commodity, if the willingness to pay for a natural environment represents a personal commitment. If so, then elements of existence value are based upon nonefficiency considerations, resulting in problems for inclusion in benefit-cost analysis.

Definitions and Measures of Existence Value

Two quotes from Krutilla (1967) and Krutilla and Fisher (1975) are appropriate to discussion of existence value.

> "There are many persons who obtain satisfaction from mere knowledge that part of wilderness North America remains even though they would be appalled by the prospect of being exposed to it" (Krutilla 1967).

and

> "Beyond this, a preserved natural environment may be regarded as an open access resource for those who benefit from its existence without necessarily appearing on site to claim their rights or benefits. In this category are:
>
> 1. vicarious consumers; those who derive satisfaction simply from knowing that certain rare or remarkable species and environments still exist, and indeed are willing to pay something for their preservation,
>
> 2. option demanders; those who value the option of experiencing sometime in the future a particular environment, perhaps for their children and grandchildren, if not for themselves; and,
>
> 3. those who may benefit from advances in medicine, agriculture, and so on, made possible by the preservation of genetic information in the more numerous wild species" (Krutilla and Fisher 1975).

Consider this taxonomy as a benchmark. The first type of person identified above, omitting the contradictory vicarious consumer nomenclature, represents the most frequently used statement for existence value. That is, a person is willing to pay for mere knowledge of existence or preservation of a natural environment. No motive other than "knowing" is suggested.

The second category, option demanders, is really two groups. The first represents the standard definition of option value as a willingness to pay to obtain an option to future personal and direct use of the natural resource in question.[3] The second group is represented by a willingness to pay for preservation, motivated by the desire that the natural resource be available for use in the future by the individual's children and/or grandchildren. This second type of value is characterized as motivated by "bequest notions" (Krutilla 1967, Randall and Stoll 1983).

The final value in this list is associated with the preservation of genetic information presumably with the opportunity of future use. Krutilla (1967) initially adopted the view that this value followed from a purely scientific viewpoint and, in particular, that there could be a unexpected value of basic research. In contrast, Krutilla and Fisher (1985) refer to values to specific individuals, presumably in the future. Arrow and Fisher (1974) refer to this category of value as a quasi-option value. Specifically, this value is associated with delaying an irreversible decision until the future, when more information may be available.

[3]A list of the essential literature which contributes to the accepted view of option demand, option value, and option price would include: Weisbrod (1964), Cichetti and Freeman (1971), Schmalensee (1972), Bohm (1975), Bishop (1982), and Smith (1983).

The early suggestions as to what constituted existence value are best represented by notions of knowledge for mere existence of the natural resource. In particular, no other motives, bequest or otherwise, were contained in the definition. Contrast this rather narrow definition with more recent literature.

Fisher and Raucher,[4] and Randall and Stoll (1983) suggested broadening the Krutilla (1967) definition of existence value. This involves the introduction of motives other than satisfaction associated with mere knowledge of existence.

Table 1 presents information pertaining to empirical studies of existence value. The various structures suggest users and nonusers as master categories as well as an all inclusive category of preservation value. Each study was examined to determine a specific existence value definition and/or the specific CVM question utilized in eliciting existence values in order to illustrate the entwining of values which might be inappropriate.

A wide variety of definitions have been used. Existence value has been defined in terms of desire for participation (Horvath 1974), desires for preservation (Meyer 1974, Schulze et al. 1980, Brookshire et al. 1983), knowledge that a resource exists (Greenley et al. 1980, Walsh et al.,[5] Desvousges et al.[6]) and non-users.[7] While all of these are related, there is clearly a lack of consensus as to the exact nature of existence value. Considerations of questionnaire design, vehicles, survey technique and sample size aside, consider the two studies focusing on water quality.[6,8]

These studies have some commonality in their approaches. Approximately the same categories of water quality were valued (e.g., boatable, fishable, etc.). However, Mitchell and Carson[8] evaluated the nation's water quality, while Desvousges et al.[6] evaluated the Monongahela river basin in Pennsylvania. The former study arrived at a $111 yearly household intrinsic value (e.g., existence value); while the latter arrived at an existence value range, depending upon whether nonusers or users are the focus, of approximately $42 to $66 per year. Clearly these results, although internally consistent, are confusing. One is for a specific river basin; the other is for the nation's rivers. Yet, the values are quite similar. Consider the dominance issue mentioned previously whereby visibility values by Brookshire et al.[2] dominated existence values in comparison to the Greenley et al. (1981) results. Clearly, the choice of value, assuming all other methodological issues aside for each study, will substantively alter the results of a benefit-cost analysis.

The confounding results might arise from the definitional approach for existence value that was utilized, or the nature of the hypothetical market, or the nature of the environmental asset, or the use of a purely hypothetical market where no previous or analogous market even existed, or the underlying motives for the expressed willingness to pay.

[4]Fisher, A. and R. Raucher, "Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives," Draft manuscript, USEPA, Benefits Staff, Office of Policy Analysis, Washington, D. C. (1983).

[5]Walsh, R. G., R. A. Gillman and J. B. Loomis, "Wilderness Resource Economics: Recreation Use and Preservation Values," Written for American Wilderness Alliance, Denver, Colorado (1982).

[6]Desvousges, W. H., V. K. Smith and M. P. McGivney, "A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvements," Report to USEPA, Office of Policy Analysis, Washington, D.C. (1983).

[7]Cronin, F. J., "Valuing Non-market Goods Through Contingent Markets," Report to USEPA by Pacific Northwest Laboratory, U.S. Department of Energy by Battelle Memorial Institute (1982).

[8]Mitchell, R. C. and R. T. Carson, "An Experiment in Determining Willingness to Pay for National Water Quality Improvements," USEPA Draft Report (1981).

Components of Existence Value

Several motivations or forms of consumption have been suggested as elements of existence value including vicarious consumption, bequest, altruistic motives, stewardship, and intrinsic characteristics. These already are incorporated into use and option values. To a large extent, the values fall into the category of sympathy as defined by Sen (1977). That is, these values generally fall into a class of externalities, which in and of itself is not a sufficient condition for inclusion within the existence value category.

Vicarious Consumption

Vicarious consumption is often stated as one motivation for an individual to hold values of existence. Existence value as represented by vicarious consumption suggests that individuals are willing to pay to know that others are using the preserved natural environment. One could analytically characterize such a motive with a model in which utility is interdependent. Such models have been examined frequently in the public finance literature and are often referred to in the context of pareto optimal redistribution (Hochman and Rodgers 1969, Olsen 1969).

Generally there are two ways in which interdependence might be represented: (1) a utility externality or; (2) a goods externality (Daly and Giertz 1972). A utility externality describes a specification for an individual's utility function as a function of goods and the utility level of some other individual; a goods externality specifies an individual's utility as a function of personal goods consumption and the consumption of a good or goods by another individual. Vicarious consumption can be characterized as an interdependence of the goods externality type. That is, an individual is willing to pay for the preservation of a natural environment because the individual obtains utility from another individual's consumption of a natural environment.

The mere presence of an interdependence in the form of a goods externality does not readily imply that voluntary individual action would fail to efficiently provide preserved

Table 1.--Findings of several empirical studies of existence value.

Authors (Description of Study)	Taxonomy of Values	Existence Value Definition	CVM Question Used to Elicit Existence Value	Mean Bid
Horvath (1973) (Benefits of wildlife in Southeastern U.S.)	Use Value (Consumptive, Nonconsumptive), Nonuse Value (Consumptive, Nonconsumptive)	Not available	"If you did not participate but wanted to, what amount of daily benefit, expressed in dollars, would you have assigned to fishing, hunting, and wildlife enjoyment?"	Nonparticipation Fishing,[1] $28.61 for each day of probable participation; Nonparticipation Hunting, $28.25 for each day of probable participation; Nonparticipation Wildlife Enjoyment, $24.52 for each day of probable participation
Meyer (1974) (Salmon in the Fraser, River, British Columbia)	Use Value, Option Value, Preservation Value	Preservation value is defined as any value associated with the salmon resource even though the respondent does not expect to use the resource simply because he or she feels the salmon should be preserved	Some people associate a value with environmental resources even though they don't expect to "use" them simply because they feel they should be preserved. Please place any value that you associate with preservation below.	Preservation Value, $223/household/year to maintain the salmon in the Fraser River
Gramlich (1977) (Benefits of attaining a swimmable level of (B) water quality in the Charles River, MA. all other U.S. rivers. Five levels of water quality: A - public water, B - swimming and wildlife, C - some wildlife, D - little wildlife, unpleasant odor, and E - health hazard)	C & D -> B	Not available	"Increase your (family's) taxes $20 each year and keep clean every river in the U.S. including the Charles River." "Clean up enough for people to swim in and fish and wildlife to live in, but not necessarily good enough for use as a public water supply without further treatment."	Inferred Existence Value, all rivers in U.S., $55.43, all other rivers than Charles, $25.49; for swimmable water quality, $/household/year
Greenley, Walsh and Young (1980) (Water quality improvements to enhance recreational enjoyment.[2] Preserved water quality in the presence of potential irreversible water quality degradation because of mining activity. South Platte River Basin; Denver, Fort Collins, Colo.)	Users (Use benefits, Intrinsic benefits [Indirect, Option, Existence, Bequest]); Nonusers (Intrinsic benefits [Indirect, Option, Existence, Bequest])	"Existence Value is the willingness to pay for the knowledge that a natural environment is preserved."		Non-recreationist: Existence, $24.98 sales tax, $6.60 water fee; Bequest, $16.97 sales tax, $5.40 water fee; Improved water quality to level A, $/household/year

[1]Participants averaged 24.9, 14.4 and 118.3 days of participation in fishing, hunting and wildlife enjoyment, respectively.

[2]Definition of recreational enjoyment was left to each individual.

(Continued) --

Table 1.--continued.

Authors (Description of Study)	Taxonomy of Values	Existence Value Definition	CVM Question Used to Elicit Existence Value	Mean Bid
Schulze et al. (1980) (Grand Canyon and National Parklands in the Southwest)	Use Value (Intrinsic Value), Intrinsic Value	Existence Value is willingness to pay for visibility in Grand Canyon, although the individual may never visit but wishes to preserve a national treasure. Users may also have existence value for clean air quality on days when they don't visit the park.	Not elicited directly	Derived
Mitchell and Carson (1981) (Improvement in levels of water quality [freshwater], boatable, fishable, swimmable; A - swimmable, B - fishable, C - boatable, D - dangerous to human health, U.S. freshwater rivers, lakes and streams)	Use Value (Intrinsic Value), Intrinsic Value	"Intrinsic category, includes a wide array of benefits ranging from indirect benefits to duck hunters of 'clean' water to pleasure gained from knowing that the nation's freshwater bodies have attained a certain quality level" Values expressed by the respondents who do not engage in instream recreation should be almost purely intrinsic.	"What amount on the payment card or any amount in-between, is the most you (your household) would be willing to pay in taxes and higher prices each year to keep the nation's freshwater bodies from falling below the boatable level where they are now. In other words, what is the highest amount you (your household) would be willing to pay for Goal C each year before you would feel you are spending more than it's really worth to you (all members of your household)."	Household, yearly; Intrinsic $111; $/household/year
Walsh, Gillman and Loomis (1982) (Maps depicting increases in level of wilderness in Colorado, 1.2 million acres, 2.6 million, 5 million and 10 million, current 1.2 million acres, proposed 5.0 million acres, proposed 10.0 million acres)	Users (Use Value, Option Value, Preservation Value [Existence Value, Bequest Value]); Nonusers (Option Value, Preservation Value [Existence], Bequest)	Existence value is the willingness to pay for the knowledge that natural habitat for plants, fish and wildlife is protected in wilderness areas.	"Assume that the only way to protect wilderness areas is for all Colorado households to pay into a special fund to be used exclusively for that purpose. What is the maximum amount of money that you would pay annually to protect wilderness areas?"	1.2 million acres, Existence $4.87, Bequest $5.01; 2.6 million acres, Existence $6.56, Bequest $6.75; 5 million acres, Existence $8.86, Bequest $9.10; 10 million acres, Existence $11.14, Bequest, $11.46; $/household/year, average size of household, 2.7.

(Continued) --

Table 1.--continued.

Authors (Description of Study)	Taxonomy of Values	Existence Value Definition	CVM Question Used to Elicit Existence Value	Mean Bid
Cronin (1982) (Improvements in water quality as described by swimming, boating, fish odor, appearance, ecology, and misc. Five levels of water quality were considered. Potomac River Basin, A - no swimming or fish, strong odor, minimal boating, open sewage; B.- no swimming, minimal fishing, boating okay, garbage smell, oil slicks; C - no swimming, safe boating, some sport fish, some occasional odor, slightly murky; D.- some swimming, good boating, most all sport fishing, no odor, slightly muddy; E - safe swimming, good boating, larger and better all sport fishing, no odor, fairly clear)	User Value, Nonuser Value	Nonuser is someone who does not use the Potomac, other rivers/ lakes, seashores, or local pools for swimming, boating, fishing, hiking, camping, picnicking, etc. Remember, try to imagine that it is as bad as Condition A and try to estimate the most you would pay each year to get it to the way it is now.	"How much would your household be willing to pay at most in terms of dollars per year to have the water in each of the conditions described on the chart? Let's start with condition B. D -> E." ---------- Yearly taxes; assume tax increase would be permanent.	User and Nonuser not separated out.
Desvousges, Smith and McGivney (1983) (Map of river and water quality, 5 levels, no activity, boating, fishing, swimming, drinking; A - safe to drink, B - safe for swimming C - game fish, D - okay for boating E - no activity, Monongahela River)	Use Value (Direct, Indirect [Existence, Aesthetic]), Intrinsic Value, Potential Use (Option Value) (No Use [Bequest, Vicarious Stewardship])	"Existence value is an individual's willingness for the knowledge that a resource exists. That is, an individual--either a user or a nonuser--might be willing to pay something to maintain a high level of water quality at a recreation site in a particular area, even though he will not use it, so that his children may have future use of the site or simply to know that the ecosystem at the site will be maintained."	"What is the most you (and your family) would be willing to pay each year in the form of higher taxes and prices for the goods you buy for keeping the river at level D where it is okay for boating, even if you would never use the river?"	(Indefinite-Implied lifetime); User Existence Value (household) $65.99; Nonuser Existence Value (household) $42.12; to keep the quality at level D assume tax and price increase would be permanent $/household/ year

(Continued) --

Table 1.--continued.

Authors (Description of Study)	Taxonomy of Values	Existence Value Definition	CVM Question Used to	Mean Bid
Brookshire, Eubanks, and Randall (1983) (Maintain Grizzly bear and Bighorn sheep habitat in Wyoming under varying levels of supply and demand uncertainty, Wyoming)	Users (Option Price), Nonusers (Existence Value, Option Price)	"Existence value refers to the willingness to pay for the existence or preservation of natural resources." Some individuals may derive satisfaction from knowing that certain species and natural environments exist and, therefore, may be willing to pay for the preservation of such natural resources.		5-year time horizon, bighorn $7.40, grizzly $24.00; 15-year time horizon, bighorn $6.90, grizzly $15.20; $/hunters/ 5 or 15 years
Stoll and Johnson (1984) (Total Value measured and components separated, Arkansas National Wildlife Refuge)	On-site Use Value, Off-site Value, (Interpersonal, Intergenerational, Intrinsic)	"Individuals produce existence activities and that the motivation for such production could be attributed to various types of altruism," interpersonal; intergenerational and Q-altruism (intrinsic).	Suppose that economic pressures and policy changes resulted in a decision to no longer fund programs to maintain the whooping crane population--a decision which would virtually insure the extinction of the whooping crane. Suppose that an independent foundation was set up for purchase and maintenance of refuge land so that species might be preserved in the future. Supporting membership in the foundation would be available for $__ per year for each person. Future access would be set up so that only those individuals who desire to visit and contribute to the Foundation each year would have the option to use the refuge areas. These people would pay no additional fees for visitation at these refuges. Other individuals who contributed, but did not intend to visit the refuges would still have the satisfaction that they helped preserve the whooping crane. If a supporting membership cost $__ per year, would you become a member and help insure the contributed existence of the whooping crane?	Per person annually, refuge visitors $9.33; Texas residents $1.08; out-of-state residents $1.24; $/person/year

environments.[9] Presumably, an individual's existence value based on this definition has relevance when the marginal utility from an additional dollar paid for preservation exceeds the marginal utility of that dollar spent on the individual's own consumption. If the inequality runs the other way, the individual would prefer the value generated from own goods consumption to preservation of nature for another's consumption. Yet, if this condition holds for an individual's decisionmaking, there would be reason to presume that the individual would voluntarily spend the additional dollar on preservation.[10]

Suppose that the other individual, which is the object of an individual's vicarious consumption, is also the object of a third individual's vicarious consumption. This case represents a multi-party externality which has characteristics of a Samuelsonian public good. All individuals vicariously consuming the nature experiences of the same individual benefit when any individual contributes to preservation. In this case, any individual may have a value and may choose to contribute to preservation. However, insufficient preservation would result, because the individual would not be influenced by the external public benefit generated for the other vicarious consumers. Assuming such multi-party vicarious consumption exists, this argument supports the idea that there may be values of economic importance that are not going to be included in market (profit or nonprofit) considerations of choices involving development or preservation of nature.

Furthermore, it is possible that conditions could exist for which a set of multi-party vicarious consumers would agree to involuntary public sector provision of preservation, even though each individual would not voluntarily act to preserve. Each individual might be worse off to contribute an additional dollar to preservation of nature, but would be better off given the multi-party externality if all contributed an additional dollar (Daly and Giertz 1972).

Although vicarious consumption motives can lead to the conclusion that market transactions will not respond to the full social benefit of preserving nature, this is not necessarily representative of existence value. First, characterization of the vicarious consumption of nature is nothing more than a specific case of a good's externality noted in the literature by Daly and Giertz (1972) and others. Second, the statement of existence value as "satisfaction simply from knowing that certain rare or remarkable species and environments still exist" is not the notion of vicarious consumption. Vicarious consumption refers to knowing others consume nature's wonders, not to a value in simply knowing nature's wonders exist and are preserved. Thus vicarious consumption falls into the class of option values. This stems from noting that another's use of nature enters the individual's utility function, and that the other individual cannot be forced to use the preserved natural environment. The willingness to pay for preservation in this case is really willingness to pay to preserve the other individual's option to use of the preserved environment.

[9]This is an important issue for the recommendations made by economists on resource policies, considering the growing interest in the significant economic activities of non-profit environmental organizations.

[10]This also suggests that such a discussion can characterize the choices individuals make when they contribute voluntarily to the preservation activities of organizations which are presumably engaged in the provision of a public good (i.e., preserved wildlife and natural environments). Weisbrod (1977) presents a strong argument that non-profit organizations provide public goods rather than private goods.

Bequest Values

A bequest value occurs when an individual wishes to pay for the preservation of a natural environment so that their children and grandchildren will have the opportunity to use the preserved environment. Many specific motives thus might underlie the act of bequeathing. A bequeathing act based upon a motive held by an individual may be considered another case of vicarious consumption and as such another element of option value. The individual motivated in this way gains utility from vicariously consuming the preserved environment through the expected use made of the environment by the individual's children and grandchildren.

If this is the case, then the altruistic bequest motive (e.g., concern for the welfare of others, as illustrated by the process of bequeathing) can be characterized analytically as an example of intertemporally and interdependent preferences where the externality is of the goods externality type. As such, a bequest motive may or may not result in economic values which are revealed by the market.

On the issue of whether markets will reflect bequest values, note that the bequest motive has been stated by Krutilla and Fisher (1975) explicitly in reference to an individual's children and grandchildren. As the discussion of vicarious consumption points out, for markets to fail, the goods externality must be multi-party. If the bequest value with respect to natural environments reflects concern for one's children and grandchildren, then a multi-party externality is not present. People are known to provide for their children and grandchildren, and it has not been unambiguously demonstrated that in general they fail to satisfy their underlying motives of bequest privately. From the social perspective, if the bequest motive is taken as a multi-party externality, the outcome is not clear, since little work has examined whether nonprofit organizations such as the Nature Conservancy provide an efficient quantity of preservation.

Furthermore, if the underlying motive of bequest is related to an individual's children and grandchildren, it is not likely necessarily to be a cause for the failure of private actions to efficiently preserve nature. A more generalized bequest motive which expresses a concern for the opportunity of future generations to utilize preserved nature could be characterized by a multi-party intertemporal goods externality which is expected to be incompletely internalized by private choices.

Thus bequest value should not be regarded as an element of existence value, because it, like vicarious consumption, can be represented by interdependent preferences. Finally, like

vicarious consumption, a bequest motive has the characteristics of option value, because those who are intended to receive the bequest cannot be forced to utilize the preserved natural bequest.

Altruism

Randall and Stoll (1983) suggest that existence value is altruistically motivated and, therefore, the exhibition of altruism is sufficient for existence value. In particular, they suggest three types of altruism: (1) interpersonal altruism, which is associated with knowing a natural resource is available for use by others; (2) intergenerational altruism, which relates to a value in knowing the resource will be available for future generations; and (3) altruism which comes from the individual knowing that the resource is undisturbed. There are two perspectives from which to view their argument.

First, altruism is simply a concern for the welfare of others. Therefore, Randall and Stoll's (1975) altruism might be included in the previous discussion as intratemporal vicarious consumption or as intertemporal vicarious consumption. Second, use of the term "altruism" may suggest that concern for others may be ethically motivated. If so, then altruism should be treated in a manner to be discussed later. As such, altruism would not appear to be at the root of expressed existence value.

Stewardship

Fisher and Raucher[4] suggested that stewardship may be a motivational element of existence value. By stewardship, they mean that an individual may be willing to pay for existence because the individual values knowing that ecological diversity is being preserved. Stewardship generally refers to managing another's property, finances, or the affairs of another. As such, it is difficult to think of an individual who is motivated by the feeling of stewardship who only personally values knowing of the preservation of ecological diversity. Thus, the stewardship motive suggests the individual as a "steward" is willing to pay because ecological diversity is part of the affairs of other individuals. Therefore, the relevant economic value is reflected by the preferences of the other person(s).

Another interpretation of stewardship is possible. From an ethical perspective it has been suggested that today's generation should make decisions concerning the use of natural resources as though the present generation does not have ownership of the resources, but is instead the steward of resources that belong to the future. As an explicit ethic concerning how individuals ought to behave, it is appropriate to treat this underlying motive for existence value as we suggest below.

Intrinsic Value

Fisher and Raucher[4] consider intrinsic benefits (value) as the sum of option values, esthetic existence values, and bequest values. These are interesting concepts for existence value, because intrinsic means "pertaining to the essential nature of a thing." In other words, intrinsic value would not involve motives for helping, providing or serving others, but involves the nature of the good or resource itself.

Randall and Stoll (1983) suggest intrinsic characteristics as a category of existence value that stems from altruism. That is, there is a willingness to pay from knowing that a natural environment is undisturbed. It is not clear why this form of willingness to pay necessarily requires altruism. Regardless, intrinsic characteristics of a natural resource, whether they are unique or just desirable, are sufficient to generate willingness to pay for knowing a resource exists. Intrinsic characteristics of a resource are what will generate, if any such value exists, an economic rather than an ethical based existence value. However, this interpretation would not include or be a part of option value or bequest value.

This semantic structure offers the dangerous possibility that any apparent willingness to pay that is associated with other definitions of value can be an intrinsic value and attributed to the essential nature of a thing. However, intrinsic seems to suggest a value which is associated with a natural resource in and of itself, regardless of an individually-held value and, therefore, would not be an economic value. However, if the value reflects nothing more than utility or satisfaction which is spawned by a perceived intrinsic attribute of the natural asset, this would seem to correspond to Krutilla's notion of existence value.

Existence Values, Counter-Preferential Choice, and Benefit-Cost Analysis

The discussion to this point leads to the conclusion that the various underlying motives or representations of existence value in the literature are inappropriate measures of an individual willingness to pay for knowing the existence of natural phenomena continues. In fact, they are all consistent with Sen's (1977) concept of sympathy. This section explores further commitment as a motive for such a willingness to pay and which is in the arena of counter-preferential choice.

Specifically, an individual willingness to pay for the existence of natural assets, in part, may be the expression of a commitment to a nonefficiency based ethic. That is, individuals may be willing to pay for a commitment (Sen 1977). If so, this would have implications for the inclusion of all empirical estimates of existence value within normative benefit-cost analysis.

Any estimates of existence value, or more generally any category of benefit, should be based on a definition that is relevant to the underlying normative framework which will be used to make the forthcoming policy recommendation.

The normative basis of the policy recommendations which follow from benefit-cost analysis is composed of three principles (Mishan 1981). The first is that the basis of value is the set of subjective valuations of the individual members of society, and nothing more. Economic value for the society arises from individual preferences which are to be taken as exogenously given. The second principle is that a desirable

policy or allocational change be characterized as a potential Pareto improvement. When analyzing a proposed change from the status quo to a new situation (or allocation), the new situation is said to be a potential Pareto improvement if those who benefit from the change can more than compensate those who are harmed by the change. This situation is regarded as a potential Pareto improvement, because the normative basis for benefit-cost analysis does not require those who benefit to actually compensate those who lose. Combining both principles results in the benefit-cost analysis being constructed as a comparison of the compensating measures of welfare change (variation or surplus) for those who would gain and those who would lose because of the proposed change.[11]

This second principle refers directly to the notion that individuals reveal their preferences in a consistent and rational manner, thus revealing a preference ordering. All that is required is consistency.

> "... no matter whether you are a single minded egotist or a raving altruist or a class conscious militarist, you will appear to be maximizing your own utility in this enchanted world ..." (Sen 1973).

For that matter, an individual who holds an environmental ethic might be consistent. The relevance to this argument is that existence value might evoke counter-preferential revelations and thus non-efficiency.

A third principle is implicit and also relevant to this inquiry. Benefit-cost analysis is based upon circumstances in which normative economic analysis suggests that market allocation of society's resources will fail to allocate resources efficiently. Normative economics holds to the principle that the proper role for public sector decisionmaking is in attempting to help the market sector attain an efficient allocation of resources. Given the presumption of market failure, normative economics recommends that appropriate public policy be determined by the mix of public sector actions which "pass" the test of benefit-cost analysis. That is, sympathy or externalities are clearly to be examined. Further, benefit-cost analysis can be viewed as representing an efficiency ethic.

Given the normative basis for the benefit-cost analysis, not all values that individuals hold can be appropriately described as an economic value relevant to benefit-cost analysis, and some of these values might even be manifested by the individual as a "willingness to pay."

Suppose, for example, individuals held an ethic, which when involved in a choice problem, is in conflict with an efficiency based ethic? What are the implications for economic analysis, particularly for the notion of existence value? Possibly many such ethics leading to counter-preferential choice exist (Bell 1968) provides one example in an analysis of how the Catholic Church's requirement of meatless Fridays affected commercial fishing.

As another example, consider market boycotts. Some religious leaders have organized boycotts of the products of television sponsors who in their view sponsor unethical television programs. Individual preference might lead to the purchase of boycotted items if it were not regarded as the wrong thing to do. Ethically motivated values and choice behaviors of this sort cannot be appropriately characterized as an argument in individual utility functions. Other examples can be found in the area of environmental ethics.

Regan (1981) argues that a necessary condition for an environmental ethic is that such an ethic "must hold that there are nonhuman beings which have moral standing."[12] A person holding such an environmental ethic would believe that we should consider how nonhuman beings will be affected by our decisionmaking regarding whether or not to take a particular action or adopt a particular policy. From an efficiency perspective this would necessarily involve a counter-preferential choice. This condition, viewed from an economic perspective, suggests that there is a difference between an ethic of the environment, and an ethic for the use of the environment.

An ethic for the use of the environment might be delineated as a management ethic which "would declare that the environment ought to be used so that the quality of human life, including possibly that of future generations ought to be enhanced," (Regan 1981). The management ethic restricts our concern only to the efficient use and interest of human beings. Clearly, benefit-cost analysis which relies on the notion of a potential Pareto improvement represents a framework for expressing a management ethic. Presumably, any one recommending that public policy with respect to wildlife and natural resources ought to be made on the basis of theoretical and applied economic analysis must hold only a management ethic.

The environmental ethic requires that a wedge exists between personal choice and welfare. Suppose an individual holding an environmental ethic has a willingness to pay for wildlife preservation. Such an individual might vicariously consume the wildlife, and/or have a willingness to pay for wildlife preservation as a bequest, but there is something more in the individual's willingness to pay if an environmental ethic is held. Vicarious consumption and bequest motives are associated with the interests of humans and an environmental ethic is concerned with more than simply human interests. An individual may be willing to pay for existence and preservation simply because it is right to try to protect wildlife against human actions which would threaten the existence of the wildlife.

It is in this context that we propose to associate at least one aspect of existence value with an individually held environmental ethic. Value associated with "simply knowing that certain rare or remarkable species and environments exist" is appropriately related to an environmental ethic if the "knowing" relates to something more than knowing, such as in the

[11] Benefit-cost analysis would recommend that all feasible alternative changes in the status quo be compared with the alternative having the greatest excess of benefits over costs being identified as the preferable alternative. In practice, such an extensive comparison of alternatives generally is not attempted.

[12] Regan also has a second condition which would characterize an environmental ethic. "An environmental ethic must hold that the class of those beings which have moral standing includes but is larger than the class of conscious beings--that is, all conscious beings and some nonconscious beings must be held to have moral standing."

case of issues pertaining to right and wrong. The extent to which these type of existence values are held is an empirical question.

If some portion of existence value stems from a commitment, such as an environmental ethic which views the world from the perspective of right or wrong, then a counter-preferential choice might be made resulting in the environmental ethic being in conflict with the efficiency ethic. Recall, however, that such a situation may not be easily identifiable. A person's choice might coincide with maximization of personal welfare, without this being the reason for the choice. Thus, ethics constrain preference motivated choices, and may actually lead a person to a choice of a less preferred item, because it is regarded by the individual as the right thing to do. This is the point Sen (1977) makes about the notion of commitment. Individuals may behave in counter-preferential ways. If this is the case, it is clearly inappropriate to treat the choice as though it were an income-constrained preferential choice.

Given that existence value is reflected by a willingness to pay for the knowledge of existence and preservation of natural assets, it is, therefore, a value relevant to efficiency, but also may be motivated by a commitment to an environmental ethic. The willingness to pay which is motivated by a commitment stemming from a counter-preferential choice should not be a value relevant to benefit-cost analysis. If there is an economic value in a willingness to pay for existence and preservation, there must be something perceived by an individual which is intrinsic to the natural asset that spawns utility or satisfaction. The intrinsic aspects of an asset and the management ethic are the foundation of economic existence value. For an individual to hold such an efficiency relevant value the individual would have to feel that the willingness to pay was not related to concern for others, present or future, nor was it related to the feeling that it is the right thing to do to help preserve natural assets.

If individuals can be motivated by a personally-held environmental ethic to pay for preservation of wildlife, there is an important implication for benefit-cost analysis. Specifically, a willingness to pay does not always represent an "economic value" as defined within the context of benefit-cost analysis. This is clearly understood when Sen's (1977) discussion of commitment is related to the case at hand. Individual's willingness to pay for preservation being motivated by a commitment to an an environmental ethic suggests that a wedge exists between individual behavior and individual choice. The normative basis for benefit-cost analysis relies on the principle that individual choice and preference are the basis for economic value. Treating an ethically motivated willingness to pay for preservation is inconsistent with the normative basis of benefit-cost analysis. The inclusion of ethically motivated values in benefit-cost analysis is inappropriate for the relevant normative economic framework.

Measurement Problems

If existence value is associated with knowing that a resource exists, an appropriate remaining question is, "How should the economic component of existence value be represented in a utility framework?" For discussion, consider a wildlife stock representation.

Miller (1981) and Miller and Menz (1979) suggest that the existence value for a wildlife species may be represented analytically by including the stock of the species in individual utility functions. Their point is that typical treatments of the optimal use of biological populations have considered only the benefits from the flow of services from the wildlife population, and have not considered "the fact that stocks of species are also arguments in individual utility functions, and that preferences for these stocks are not revealed in market-determined prices."[13] Vousden (1973), Smith (1977) and others have also included stock in utility functions. Plourde (1975) treats the stock of wildlife in utility functions, suggesting that the existence of species is an intergenerational public good.

It is not clear whether the notion of existence value can be meaningfully expressed by including stock in the specification of individual utility functions. The models of Miller (1981) and Miller and Menz (1979) make no distinction between existence value and nonconsumptive user values associated with hiking, backpacking, photography, etc. This certainly would confound analytical efforts. Further, including a stock argument in utility also implies that people are willing to pay greater (but marginally decreasing) amounts for an ever larger stock of wildlife under conventional assumptions. That is "smoothness" over a range of stock sizes is assumed. This may be inappropriate in the existence value context.

The size of a wildlife population may be perceived by individuals as related to its potential for existence, and, as such, a particular stock size above a survival threshold level would lead to the belief that the species was safe. Falling below this threshold, people would perceive a threat to the existence of the species. One might even speculate that individuals perceive the threat of extinction in such a discrete way that the existence value for the species associated with stock sizes greater than zero but less than this threshold would be identical in magnitude. In other words, a-threat-is-a-threat, regardless of the size of the threatened population. Traditional convexity assumptions are inappropriate when discussing existence value. Further problems, however, remain, which even non-convexity recognition would not resolve.

What is the utility value associated with a stock which is zero in size? Is there no satisfaction? This usually is the case with preferences for other goods. However, there is something different about a zero wildlife stock utility argument and a zero

[13]The choice of "fact" in this statement is unfortunate. The authors make little attempt to argue theoretically in support of this fact, nor do they present empirical verification of the "fact." There are several reasons why someone might have a preference for a stock of wildlife, including reasons relating to measurement and motivation ("ethical" or "preference").

for the utility argument corresponding to something like video game consumption. In order to know about the utility associated with a zero for wildlife stock we need to know something about circumstances. For example, suppose individuals believe that the extinction of a species resulted from the economic decisions made by themselves and their contemporaries. In this case, the zero in the utility function corresponding to a wildlife population might well be associated with negative utility.

Suggesting that circumstances may be important relates to observations made by Plourde (1975) and Randall and Stoll (1983), that suggest information plays an important part in the determination of existence values. "It is only when a species becomes endangered that people become aware of their preference for preservation and become willing to pay for it" (Plourde 1975). Also consider a bit of anecdotal empiricism regarding the recent snail darter situation.

> "Until its discovery in 1973, its existence demand was zero. Its existence demand rose rapidly as it was accepted as a separate species and listed as endangered, and as knowledge of its existence and its plight spread rapidly among the public" (Randall and Stoll 1983).

These statements may accurately reflect elements of the value people associate with existence of species of wildlife. However, simply including a stock measure in a utility function cannot adequately characterize the concerns of these authors. Surely, including a stock utility term cannot characterize Plourde's (1975) assertion that people become aware of preferences for preservation only when a species' existence is threatened.[14]

The obvious question is, "What sorts of things can be legitimately included as an argument in a utility function?" Can we just assume anything as an argument in a utility function?[15] Certainly it is legitimate to write utility as a function of the number of hamburgers, the number of cokes, etc. People are believed to have desires, wants, preferences for such items; but it should be noted that these items have no other special significance apart from the fact that they are desirable.

It is important to ask about the motives that lead people to pay for wildlife stock maintenance. Suppose you ask people why they spend money on hamburgers, and also why they spend money on efforts to save the blue whale. Will the nature of the answers to the question be similar, or perhaps dissimilar in an important way? If the answers are similar, it seems legitimate to include measures of both items as arguments in the individual's utility function. If the reasons given are dissimilar in an important way, then we should probably be uncomfortable about including both items in the individual's utility function, or at least about inclusion in the same way.

In summary, expressing existence value as a stock argument in a utility function is incapable of expressing the idea of a value in merely knowing of the continued existence of a wildlife species. Such a representation suggests aspects of existence value which are inappropriate, while at the same time fails to characterize other aspects of relevance. Furthermore, it seems important to describe the motivation for an individual to gain utility from a stock of wildlife. Interest in such a motivation not only suggests that the stock utility representation is ill-conceived, but also that the true character of an existence value is difficult to describe as a simple want or preference.

Conclusions

Many questions remain about the semantic structure known as "existence value." While we argue for a return to the uncluttered world as originally proposed by Krutilla (1967), how then do we measure economic existence value for potential inclusion in a benefit-cost analysis? That is, it is fine to argue that intrinsic characteristics are the root, but how is a willingness to pay preference based measure obtained? Can the contingent valuation methodology accomplish this through a hypothetical market? What about recent arguments that suggest a hypothetical market for existence value would lead to inaccurate values? What about expressions of WTP that are non-efficiency based? Will the CVM allow distinctions amongst alternatives? The list of possible questions is quite long.

Consider initially the issue of efficiency versus ethical confounding. Either all existing empirical measures of existence value to date are efficiency based expressed preferences via a willingness to pay measure, or existing empirical measures are confounded, or they are all willingness to pay measures stemming from non-efficiency ethics. Certainly we can directly inquire as to individuals motives and ethical structures underlying statements of willingness to pay. Designing a series of experiments incorporating these concerns seems possible.

References

Arrow, K. J. and A. C. Fisher. 1974. Environmental Preservation, Uncertainty, and Irreversibility. Quarterly Journal of Economics, p. 313-319.

Bell, F. W. 1968. The Pope and the Price of Fish. American Economic Review 57(5), Part I (December).

[14]This is not meant to overemphasize the importance of these authors' observations for an evaluation of the adequacy of a stock utility argument to express existence value. More importantly, they seem to suggest there are some aspects of existence values for wildlife that will be difficult to account for in the usual types of economic models, and furthermore, that all of existence value may not be totally an economic value in the usual sense. These authors' observations fit very well with treating existence values as being motivated by an individually-held nonefficiency based ethic.

[15]Rothenberg (1962) asks what are the alternatives to which preferences are to refer as far as normative economics is concerned. His analysis concludes that individual preferences about welfare criteria should be excluded from consideration as arguments of the individual utility functions that constitute the basis for economic value in the normative framework of benefit-cost analysis.

Bishop, R. C. 1982. Option Value: An Exposition and Extension. Land Economics, 1-15.

Bohm, R. 1975. Option Demand and Consumers' Surplus: Comment. American Economic Review, 733-36.

Brookshire, D. S., L. S. Eubanks, and A. Randall. 1983. Estimating Option Prices and Existence Values for Wildlife Resources. Land Economics, 59(1):1-15.

Cummings, R. G., D. S. Brookshire and W. D. Schulze. 1986. Valuing environmental goods: An assessment of the contingent valuation method. Rowman & Allanheld, Publishers. Totowa, N.J.

Daly, G. and F. Giertz. 1972. Benevolence, Malevolence and Economic Theory. Public Choice, 1-19.

Freeman, A. M. III. 1984. The Sign and Size of Option Value. Land Economics, 60:1-13.

Graham, D. A. 1981. Cost Benefit Analysis Under Uncertainty. American Economic Review, 71:715-725.

Gramlich, F. W. 1977. The Demand for Clean Water: The Case of the Charles River. National Tax Journal, XXX:183-194.

Greenley, D., R. Walsh and R. Young. 1980. Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality. Quarterly Journal of Economics, 96:657-672.

Hochman, H. M. and J. D. Rodgers. 1969. Pareto Optimal Redistribution. American Economic Review, 542-557.

Horvath, J. C. 1974. Economic Survey of Southeastern Wildlife and Wildlife-Oriented Recreation. Transactions of the 39th North American Wildlife and Natural Resources Conference. p. 187-194.

Krutilla, J. 1967. Conservation Reconsidered. American Economic Review, 777-786.

Krutilla, J. V. and A. Fisher. 1975. The Economics of Natural Environments. Baltimore: Johns Hopkins University Press for Resources for the Future.

Meyer, P. A. 1974. Recreation and Preservation Values Associated with the Salmon of the Fraser River. Information Report Series, No. PAC/N-74-1, Vancouver, Canada: Fisheries and Marine Service.

Meyer, P. A. 1978. Updated Estimates for Recreation and Preservation Values Associated with the Salmon and Steelhead of the Fraser River. Vancouver, Canada: Fisheries and Marine Service.

Miller, J. R. 1981. Irreversible Land Use and the Preservation of Endangered Species. Journal of Environmental Economics and Management, 19-26.

Miller, J. R. and F. C. Menz. 1979. Some Economic Considerations for Wildlife Preservation. Southern Economic Journal, 45:718-729.

Mishan, E. J. 1981. Introduction to Normative Economics (New York: Oxford University Press).

Olsen, E. O. 1969. A Normative Theory of Transfers. Public Choice, 39-58.

Plourde, C. 1975. Conservation of Extinguishable Species. Natural Resources Journal, 15(4):791-797.

Randall, A. And J. R. Stoll. 1983. Existence Value in a Total Valuation Framework. *In:* Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Robert D. Rowe, and Lauraine G. Chestnut, editors. Westview Press, Boulder, Colo.

Regan, T. 1981. The Nature and Possibility of an Environmental Ethic. Environmental Ethics, 19-34.

Rothenberg, J. 1962. Consumers' Sovereignty Revisited and the Hospitability of Freedom of Choice. American Economic Review, 269-283.

Schmalensee, R. 1972. Option Demand and Consumers' Surplus: Valuing Price Changes Under Uncertainty. American Economic Review, 813-824.

Schulze, W. D., D. S. Brookshire, E. G. Walther and K. Kelley. 1980. Methods Development for Environmental Control Benefits Assessment. Volume VIII, The Benefits of Preserving Visibility in the National Parklands of the Southwest. USEPA, Office of Exploratory Research, Office of Research and Development, Washington, D. C.

Sen. A. 1973. Behavior and the Concept of Preference. Economics 241-259.

Sen A. 1977. Rational Fools: A Critique of the Behavioral Foundations of Economic Theory. Philosophy and Public Affairs, 6.

Smith, V. K. 1983. Option Value: A Conceptual Overview. Southern Economic Journal, 654-668.

Smith, V. K. 1985. Cost-Benefit Analysis Under Uncertainty: Further Comments. Working Paper No. 85-W12, Department of Economics, Vanderbilt University.

Smith, V. L. 1977. Control Theory Applied to Natural and Environmental Resources. Journal of Environmental Economics and Management, 1-24.

Vousden, N. 1973. Basic Theoretical Issues of Resource Depletion. Journal of Economic Theory, 126-43.

Weisbrod, B. A. 1964. Collective-Consumption Goods. Quarterly Journal of Economics, 471-477.

Weisbrod, B. A. 1977. The Voluntary Non-profit Sector. Lexington, Mass.: D. C. Heath and Company.

Intrinsic Values in Benefit Cost Analysis

V. Kerry Smith[1]

Abstract--This paper reviews the literature on intrinsic or nonuse benefits as it has been developed for resource and environmental applications and proposes a consistent set of definitions for *ex ante* use and nonuse values. The conceptual framework demonstrates how the conventional treatment of use, option and existence values is inadequate. Option value, the difference between the option price and expected value of consumer surplus, is shown to arise from comparing two different conceptual frameworks for describing how individuals value resource changes under uncertainty. The *ex ante* or planned expenditure function is defined and used to provide a taxonomy for use and nonuse values when individuals decisions are made under uncertainty. The paper concludes by considering the prospects for measuring nonuse values for natural and environmental resources and the implications for the treatment of nonuse values in conceptual analyses underlying the practices of benefit cost analysis.

Benefit-cost analysis is a set of tools that policymakers can use to judge whether the activities under consideration (e.g., public investments, regulations of private sector actions, etc.) move the economy toward a more efficient allocation of resources. In benefit-cost analysis, positive, aggregate net benefits imply the prospects for an improvement in the status quo; anything else does not.

In the three decades since its acceptance in economics, research in this area has sought to extend the types of benefits that could be measured. The earliest contributions to the field tended to rely on market prices as measures of the dollar benefits associated with public projects (Krutilla 1967). This practice limited the types of goods and services that could be valued to those exchanging on markets. Although public activities provided other outputs, because their valuation was judged to be difficult, these categories of benefits were labeled "intangibles" (Haveman and Weisbrod 1975, Bishop and Cicchetti 1975, Smith 1976).

One of the most important contributions of the research in this area has been the progressive ability to move goods and services from the intangible category (or incapable of valuation) to the measurable. For example, the recreational services provided by projects associated with dams for hydroelectric power and flood control were regarded as intangible until the development of the Travel Cost Model for estimating the demand for outdoor recreation sites. More recently, the hedonic housing market approach has provided a theoretical and, in some cases, empirical basis for valuing site-specific amenities such as air quality (see Bartik and Smith 1987).

One of the "frontiers" in benefit measurement appears to be associated with intrinsic or "non-user" benefits. To date, there has not been an accepted set of definitions or procedures for measuring these types of benefits. They arise largely from two modifications to the conventional model of consumer behavior. The first, identified originally by Weisbrod (1964), relates to the role of uncertainty for an individual's valuation of certain types of resources. It was argued that, given uncertainty in the use of a resource or its availability in the future, a risk-averse individual might be willing to pay more than his (or her) expected consumer surplus (from that future use) to change the conditions governing the availability of the resource.[2] Second, individuals may value resources that they do not "use" in terms that would correspond to conventional views of consumption. Krutilla (1967) first proposed this source of benefits, distinguishing bequest motivations from those values identified as "existence values."

These sources of benefits differ in an important respect from early types of intangible benefits. Neither is the result of the process of consumption as it is usually described in economic models. The first arises from motivations that parallel the reasons why individuals purchase insurance or diversify their investments (or activities) in an attempt to reduce their risk.[3] In contrast, existence values seem to conflict with the conventional theory of consumer behavior, implying that individuals can gain utility from resources without consumption. Consequently, several economists have

[1]University Distinguished Professor, Department of Economics and Business, North Carolina State University, Raleigh.

[2]The use of the term "might" in describing the relationship between an individual.s payment and the expected consumer surplus is deliberate. As the past literature has demonstrated, determination of the sign of option value (i.e., the payment or option price less the expected consumer surplus) depends on the assumptions made in characterizing the uncertainty facing the individual and the opportunities available for responding to it.

[3]Most empirical studies of the magnitude of option value have found it to be as large as the expected consumer surplus (Fisher and Raucher [1984]). By contrast, theoretical attempts to bound option value seem to suggest it should be quite small in relation to user values (Freeman 1984).

argued that the only legitimate basis for these values is some form of altruism (McConnell 1983, Randall and Stoll 1983).

One purpose of this paper is to argue that neither source of intrinsic benefits must be regarded outside conventional models of consumer behavior. Both are compatible with established models of consumer choice. However, the transition from a consistent conceptual framework for each to their measurement is not clearcut. Consequently, there is ample reason for concern about the use of these concepts to justify a variety of types of policy actions.

Integrating Intrinsic Values Into Consumer Choice Theory

It is important to provide some background on the implicit assumptions underlying conventional models of consumer behavior, especially in relation to existence values, because these have been regarded by some analysts to be at variance with most models of consumer choice. That is, under a narrow interpretation of existence values, the use of a resource is explicitly precluded. Therefore, an individual's valuation of a resource under these circumstances can only arise from some form of altruism. This definition seems to result from a narrow reading of a few key phrases in Krutilla's (1967) original discussion of existence values.

It is more reasonable, and ultimately more productive, to consider what was intended in his discussion. Krutilla (1967) sought to distinguish the observable in situ use of an environmental resource from other not easily observable uses for desiring that a particular resource be maintained or enhanced in some respect.

The act of consumption of goods or services in conventional models often assumes the commodities involved are exhausted or "used up" after the individual has purchased and "consumed" them. This perspective is satisfactory for many goods, such as food, but not for others with consumer durables, a notable example of the latter set. However, even within food, purchase and consumption are not always synonymous. Purchase for storage may be an important component of some short-run demand responses (e.g., hoarding of commodities thought to be subject to some future scarcity).

There is a spectrum of goods varying in durability. In each case, there is a relationship between the purchase and time sequence of use. Based on market transactions alone little is known of the nature of instantaneous demands for the services of an automobile, washing machine, or air conditioning unit. Knowing that an anticipated time sequence of uses motivated the initial purchase, it could be assumed, following the analogy to capital theory, that there are conditions when these actions would be completely consistent with those taken in the presence of ideal rental markets for the services involved. Another case that combines several dimensions of the role of time in consumption arises in modeling an individual's decisions for collectible items -- coins, stamps, antiques, etc. There is usually an asset motivation for these decisions arising from the expectation of scarcity-induced price increases. However, there also may be consumption services in varying degrees provided by the items. The purchase decisions will reflect both of these motivations.

Becker's (1965) early work on the household's allocation of time, and with it the household production framework, has drawn attention to some of these issues. This general line of inquiry is relevant to existence value, because a full evaluation of existence values requires a generic analysis of the way economic models implicitly describe processes of consumption and use of a commodity. In short, to integrate existence values into a model of consumer choice, we must first consider how we use the commodities thought to give rise to existence values. Does the observed action of purchase convey all the information necessary to describe individuals' demand for the services of commodities that might provide existence values?

Consider another example that is more relevant to the class of allocation decisions usually involved in existence value discussions. Walsh et al. (1984) reported the results of a contingent valuation analysis of the wilderness areas in Colorado, eliciting bids from a sample of Colorado residents for differing amounts of land in the wilderness designation. For wilderness recreation, the act of purchase is treated as the trip to the wilderness area. The question relevant to existence values for wilderness areas is whether such trips are the only uses of wilderness. Traditional measures of consumption and use, for example, would exclude the researcher who uses the wilderness (and the wildlife it supports) in his (or her) research.

Moreover, even precluding these technical and scientific uses that are not reflected in the available measures of consumption, there are additional activities, often involving a reasonably large part of some household's leisure time. Individuals join environmental groups, and subscribe to periodicals that describe recreational, sporting, or scientific activities made possible because of the availability of wilderness. These sources of information may be important to some individuals. The growth of environmental and resource related programming on public television is another type of use that is not reflected by the conventional description of purchase and consumption.

These examples are forms of consumption that would not be reflected by the models available to estimate user values.[4] If existence value is defined to preclude any type of use, then they would be omitted from this classification also. However, an approach that seems more consistent with Krutilla's (1967) objective would be to recognize that for some commodities,

[4]Mendelsohn (1984) has recently questioned the inclusion of some forms of vicarious consumption or secondary use (in his terms) on the grounds that it inevitably leads to higher future use levels and, therefore, is more appropriately captured at that stage. Unfortunately, there is no formal model presented to derive this conclusion. The phenomena of learning-by-doing (or "indirect doing") and consumption decisions are a complex process to model. There are many plausible descriptions of this behavior that would not be consistent with his conclusions. To accept his arguments one must effectively assume that these secondary uses are exclusively desired for information and do not represent utility enhancing acts.

the act of purchasing the good or its services is only one of the ways it can be used. Conventional definitions of user values have treated purchase and use as equivalent. While this is correct for many goods (and circumstances), it may not be for those environmental resources where as existence values may be substantial.

Recognition of a role for these types of consumption in what are termed "existence values" does not preclude the inclusion of altruistic motives as well. Existence value would reflect the types of consumption and indirect (or vicarious) use that are not measured by conventional approaches to describing consumption as well as altruistic behavior. In many respects this approach combines the strategies proposed by McConnell (1983) and Randall and Stoll (1983).

McConnell (1983) followed conventional practice and focused on values in excess of those realized through the "purchase" of the services of the resource.[5] Thus, if the character or quality of a resource changes, then the Hicksian compensating surplus associated with that change defines the resource value. It includes a change in user and existence values. The former is present because the resource is used by purchasing a good or resource related to the resource, and the latter reflects the change in the value of the resource to the individual in the absence of in situ use. This definition implies that weak complementarity cannot hold.[6]

Our proposal amounts to suggesting that some additional purchases (or allocations of time) may be changed because of a change in a resource. They represent values derived in circumstances where purchases cannot be attributed to the use of the resource or where the actions associated with consumption are not observed. They may be internal to the household (i.e., reallocations of time to reading particular stories in periodicals or viewing specific television programs, etc.). These would be captured in McConnell's (1983) definition, because only one commodity is assigned to use. Implementation of the narrow definition of existence values, as proposed by Randall and Stoll (1983) or Mendelsohn, would require enumeration of all actions associated with consumption and attribution of the purchases of goods or services assumed to be describing uses of the resource. To the extent that some of these consumption choices serve multiple objectives, use measures require a separation of the role of the resource for these activities.

To consider the relationship between the user value and the various components of intrinsic values, it is desirable to evaluate the implications of how a model imposes restrictions on the household's utility function in terms of the relationship between a private good, x, and an environmental resource, R. Equation [1] provides the usual formulation.

$$U = U(x, R). \qquad [1]$$

There are many choices for the treatment of R in the determination of utility. For example, we could have assumed that R contributed to the production of household service flows or basic commodities (Becker 1965), expressed U(.) in terms of these service flows, and then defined production functions for the service flows. In the two service flow case with x and R as inputs, we need to distinguish whether R can be allocated among the activities or not (we assume x can). The two characterizations would imply a utility function as follows, with $f_i(.)$ representing the household production functions and x_i and R_i the allocations to the i^{th} activity.

$$U = U(f_1(x_1,R_1), f_2(x_2,R_2)) \qquad [2]$$

(x and R allocated)

$$U = U(f_1(x_1,R), f_2(x_2,R)) \qquad [3]$$

(x allocated)

The distinction between [1] and [2] lies in the fact the R is a "public" input to the household under formulation [3] and not in [2]. Either specification could be treated as providing a rationale for use and existence values, depending on what was assumed about the information available on household choices of x and R and the final service flows associated with $f_1(.)$ and $f_2(.)$.

Further illustration of the implications of the structuring of the role for R in individual preferences arises in the Bockstael-McConnell (1983) analysis of welfare measurement using a household production framework. They noted that it is possible to measure the individual's valuation of a change in the environmental resource (as a non-marketed good) using the demands for one or more marketed goods that are linked to R in a specific manner. These linkages make the individual indifferent to the level of R when the marketed good (or goods) is(are) not purchased. In their analysis, R enters the utility function and not the production functions for household service flows as in equations [2] and [3].[7] R must be assumed to be weakly complementary to the set of final service flows involving the specific market good as an input. Moreover, this input good must be an essential input to the production of these final service flows.

These conditions effectively "tie" R to the purchase and consumption decisions for a set of marketed goods. Therefore, they eliminate the prospect for existence values. That is, if existence values reflect both enjoyment derived from altruistic and bequest motives and from consumption that is independent of observable acts of use of the resource, then their assumption appears to preclude both. While it might be argued that indirect consumption could be treated as one of

[5]He does express skepticism as to the likely magnitude of these values.

[6]Weak complementarity arises when there is a specific link in an individual's preference function for two commodities. Maler (1974) first proposed this case when one good was private and the other public (or at least not available through markets). It requires that there exists a price for the private good where the quantity demanded of the private good will be zero; and that at that price (and consumption level of the private good) the marginal value of the public good is zero. For discussions of its implications see Freeman (1979) and Bockstael and McConnell (1983).

[7]Equivalent conditions could be stated if we assumed that R entered the production functions.

the final service flows, their approach to measuring the individual's valuation maintains that decisions on selections of all the marketed commodities can be observed and are associated with the resource (as a result of the weak complementarity assumption).

Bockstael and McConnell (1983) claim too much for their arguments in suggesting that:

> "...it does not matter whether the link between the public good and the produced commodity is through the preference or production function as long as the public good is of no value when the commodity is not produced." (p. 813)

To use their approach to measure the demand for R with data on the purchased goods, we must assume that R is of no value without the purchased commodities. This hypothesis cannot be tested with information on the consumption choices for the purchased goods alone. Although the source for the "no value" outcome whether preferences or production technology is not important to their logic, it is important to gauging the plausibility of the assumptions as a maintained hypothesis.[8]

Randall and Stoll's (1983) formulation of existence values would introduce another function as a separable determinant of utility. This function would involve only the resource, R. This separate contribution could arise because the individual's well being is affected by other economic agents' utility functions at the same time or at different points in time. It might also arise from components of other households' utility functions (i.e., the altruism is a concern for assuring others enjoy the natural environment; comparable psychic income would not be derived from an income transfer).

Although it is easy to characterize the "source" household's preferences for R, any of these assumptions effectively reduces to the specification given in equation [1] in terms of their empirical relevance without information on patterns of usage or specific assumptions on functional structure used to describe utility. Thus, if we assume the household's behavior is best described as a process where each selects good and services to maximize a specified utility function subject to a budget constraint, then McConnell's (1983) use of an expenditure function offers the most direct way to characterize the relationship between user and existence values. By specifying a role for R in the expenditure function that is distinct from that which arises because of the assignment of one or more purchased goods as reflecting the "use" of the resource, a corresponding role for existence value in the utility function is implied. Moreover, the origins of the existence value can be attributed to any or all of the motives discussed previously.

Let E(.) designate the expenditure function defined formally in equation [4].

$$E(P_1,P_2, ...P_n,R,\bar{U}) = \min [\Sigma_i P_i x_i \mid \bar{U} = U(x_1, ...,x_n,R)] \quad [4]$$

If one commodity reflects use (e.g., x_1), then the user value derived from any level of the resource (the compensating variation, CV in this definition) is given in equation [5].

$$CV = E(\bar{\bar{P}}_1,P_2, ...P_n, R, \bar{U}) - E(P_1,P_2, ...P_n, R, \bar{U}) \quad [5]$$

with $\bar{\bar{P}}_1$ - the price at which none of the services of the resource would be demanded. This is simply the area under the Hicksian demand for x_1 between the existing price, P_1, and the price intercept, $\bar{\bar{P}}_1$.

If there were no resource available (i.e., R = 0), then the user value also would be zero. The total value (user and existence) is defined by the difference in expenditures, holding prices constant, but considering the effect of the level of resource available -- zero versus some level R.[9]

$$TV = E(P_1, P_2, ...P_n, 0, \bar{U}) - E(P_1, P_2, ...P_n, R, \bar{U}) \quad [6]$$

One important aspect of the interpretation of this equation and of existence value, depends on understanding the implications of the link specified between x_1 and R. It implies that there is an additional constraint on the minimization process defined in [4]; x_1 cannot be different from zero unless $R > 0$.[10] Thus, regardless of the price specified for x_1 the level of consumption will be zero if there is no resource. While this seems obvious, it has not been fully appreciated in earlier discussions of the McConnell (1983) framework. It implies, for example, that the expenditures when R= 0 will be invariant to the choice of a value for P_1 (for example, $E(P_1, ...P_n,0,\bar{U}) = E(\bar{P}_1, ...P_n,0,\bar{U})$). Consequently, existence value can be defined as the difference in expenditures that would be made at the choke price for x_1 with the environmental resource at zero or a level R as in Equation (7)[11] and the sum of use and existence values will correspond to the total value.

[8]Their specification is not the same as a technical and observable link between a private and a public good. For example, air quality conditions will be specific to a geographic location. This is observable. In interpreting a distinction discussed in Smith (1981) Bockstael and McConnell (1983) seem to treat this technical link as equivalent to an assumed technological association between a private and public good, as through a household production function. There is an important distinction. The first is observable and, therefore, subject to confirmation. The second is not observable with the present information. Therefore, either assume it is present or use indirect methods to attempt to verify the association. However, these indirect approaches do not exhibit sufficient resolution of the processes involved to permit the testing of the features implied by Bockstael and McConnell's (1983) analysis.

[9]This definition exactly parallels McConnell's work, except he focused on changes in the amount of the resource available, rather than its elimination.

[10]We could also, without changing the implications of the analysis, assume that R had to exceed some positive threshold for the services to be available. This case might be more appropriate to problems involving endangered species.

[11]Equation [7] corresponds to Bockstael and McConnell's (1983) equation [16] and, therefore, provides a clear demonstration that their method assumes existence values will be zero.

$$EV = E(\bar{P}_1, P_2, \ldots P_n, 0, \bar{U}) - E(\bar{P}_1, P_2, \ldots P_n, R, \bar{U}) \quad [7]$$

If additional purchased commodities are associated with use of the resource, the price arguments in equations [5] and [7] which differ would be increased to include them (McConnell 1983).

The other component of intrinsic value arises from the influence of uncertainty for individual decision-making and valuation. Since all of the preceding analysis has been undertaken with the assumption of consumption decisions given certainty it should not be surprising that the currently proposed benefit taxonomies (Mitchell and Carson[12] or Desvousges et al. 1983) encounter difficulties in consistently integrating the constituent elements within a single behavioral framework. To consider option value one must introduce uncertainty into the process -- either uncertainty as to whether the services will be demanded, uncertainty as to their supply, or both.

The following analysis utilizes the conventional, timeless analysis of option value, beginning with the assumption that the uncertainty relates to an individual's demand for the site's services. Once the option price is paid, supply of the resource is assumed to be available.[13,14] This approach uses a contingent claims framework with state-dependent preferences to describe the individual's choice problem (Smith 1983). It implies that the model is describing planned actions, contingent on a state of nature being realized.[12]

Nonetheless, all of the arguments concerning the implications of motives in defining a role for resources in the utility function as they have been developed in the certainty case are relevant to this case, and would apply to each of the state-dependent utility functions. Indeed, consumer preferences and those constraints affecting decisions can be represented with an expenditure function for this case as well. However, in this case it is planned expenditures, $\tilde{E}$ to realize an expected utility level, and would be defined by equation [8].

$$\tilde{E}(P_{11}, P_{12}, P_{21}, P_{22}; \pi_1, 1-\pi_1; R; \overline{EU}) = \text{Min} \left[\sum_{i=1}^{2} \sum_{j=1}^{2} P_{ij} x_{ij} \overline{EU} \right] \quad [8]$$

$$= \pi_1 U_1 (x_{11}, x_{12}, R) + (1-\pi_1) U_2 (x_{21}, x_{22}, R)]$$

To simplify matters, two commodities and two states of the world are assumed. This implies four contingent commodities, designated with the double subscripts on both the planned consumption, x_{ij}, and prices, P_{ij} (with i designating state and j the commodity). Simmons (1984) proposed similar formulation to provide a measure for a multivariate risk premia with discrete probability distributions.[15] However, his analysis did not recognize the potential value of the framework for benefit analysis under uncertainty.[16] Indeed, this approach provides an alternative to Graham's (1981) willingness to pay locus and allows the definition of valuation concepts that explicitly reflect the implications of the opportunities for individual adjustment to risk. This conclusion follows from the fact that the prices of contingent claims are arguments along with the probabilities of the states of nature of the planned expenditure function. The valuation concepts proposed for risk changes will correspond to Simmons' (1984) proposed measure for a risk premium.[17] Moreover, they can be shown to correspond to the option price when there is no possibility of state dependent payments for the risk change.

To examine the potential value of this framework for benefit analysis under uncertainty and as a comprehensive framework for classifying the sources of individual benefits from public policies that involve changes in risk, consider the conventional definition of the option price. In this framework, it can be described as the maximum payment that would be made in all states for the assured availability of the resource, R. Because this payment is made partly because of the possibility of future use, the definition must allow for that use. Moreover, it is important to recognize that option price implies a specific institutional framework for adjusting to risk. That is, it is a constant payment regardless of the state of the world realized.

As in the case of certainty, to allow for planned use of the resource, a commodity must be designated as representing use. Following conventional practice, assume the two states of nature correspond to the cases where an individual has a demand for use and where he (or she) does not. Thus, there would be no role for the price of the commodity representing use in the no demand state. Following earlier practice, assume it is x_1. To maintain a constant state dependent payments for access to the resource regardless of the state of the world and the level of use of the resource requires that $P_{11} = 0$. (Note there is no demand for x_1 in state two by assumption; so x_{12}

[12]Plummer, Mark L. and Richard C. Hartman, "Option Value: A New Approach," Economic Inquiry, Vol. 24 (July 1986):455-471.

[13]There have been a variety of generalizations to the option value literature, including consideration of: (a) the effects of time sequencing in decisions and the ability to partially resolve some aspect of the uncertainty with time; (b) the prospects of supply and demand uncertainty in a timeless framework; and (c) the use of option price as a payment for a change in the likelihood of uncertain events, but not the elimination of the uncertainty.

[14]Bishop, Richard C. "Option Value or Option Price: Principles for Empirical Resource Valuation Under Uncertainty," Department of Agricultural Economics, University of Wisconsin-Madison, April 12, 1984, unpublished paper.

[15]A concept similar to this planned expenditure function was originally introduced by Cook and Graham (1977) for one case -- actuarially fair markets in contingent claims. It can also be treated as generalization of Graham's (1981) willingness to pay locus, allowing for the household to plan different levels of consumption under the various states of the world. Graham's (1981) locus reflects this consumption alternative by allowing differing payments for the same assumed consumption levels in all states.

[16]In discussing his proposed risk premium measure, Simmons (1984) draws an analogy to valuation measures in the case of certainty.

[17]The most direct correspondence can be seen in his case where risk premia are defined for distributions with differing probabilities but equal mean outcomes.

would not enter the state two utility function.) With these amendments it is possible to define the option price in equation [9].

$$OP = \tilde{E}(\bar{0},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ 0;\ \overline{EU}) - \tilde{E}(\bar{0},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ R;\ \overline{EU}) \quad [9]$$

where $\bar{0}$ designates that $P_{11} = P_{21} = 0$. While there seems to be a parallel between this definition and the definition of the resource value under the case of certainty, there are important differences. First, the expenditure functions are quite different. $\tilde{E}$ (.) is not simply the expected value of the expenditure functions corresponding to each state dependent utility function.[18] Second, this function describes expenditures on contingent claims.

With equation [9] it is possible to illustrate the difficulties posed by the desire for a single framework to include user and intrinsic values. These difficulties arise from the different perspectives associated with the values in the definitions. That is, an ex ante perspective is implied by the definition of option price while an ex post perspective is associated with the conventional definition of the expected consumer surplus. Option value actually involves mixing the two perspectives. That is, in our notation, it requires the difference of the two types of expenditure functions (i.e., option value = OP - $\sum \pi_i CV_i$). This result is illustrated in equation [10], by adapting the definition of CV in equation [5] for the case of two commodities.

$$OV = \tilde{E}(\bar{0},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ 0;\ \overline{EU}) - \tilde{E}(\bar{0},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ R;\ \overline{EU}) - \pi_1 [E_1(\bar{P}_1,\ P_2,\ R,\ \bar{U}) - E_1(P_1,\ P_2,\ R,\ \bar{U})] \quad [10]$$

where E_1(.) corresponds to the conventional expenditure function implied by the utility function in state one
Without a specific relationship between the $\tilde{E}$ (.) and E_1 (.) expenditure functions it is difficult to specify the sign of this difference.

The relationship to Simmons' (1984) findings can be readily established by changing the source of uncertainty facing the individual to supply uncertainty. In this case, the individual is certain that the services would be demanded, but is uncertain of their availability. Equation [8] would be restated for this situation as:

$$E^*(P_{11},\ P_{12},\ P_{21},\ P_{22};\ \pi_1,\ 1-\pi_1;\ R;\ \overline{EU} = \text{Min}\left[\sum_{i=1}^{2}\sum_{j=1}^{2} P_{ij}\, x_{ij} \,\middle|\, \overline{EU}\right] = \pi_1 U_1(x_{11},\ x_{12},\ 0) + (1-\pi_1) U_2(x_{21},\ x_{22},\ R)] \quad [11]$$

[18]Smith, V. Kerry, William H. Desvousges and A. Myrick Freeman III, Valuing Changes in Hazardous Waste Risks: A Contingent Valuation Analysis, Vol. I, Draft Interim Report prepared for U.S. Environmental Protection Agency, Vanderbilt University, February 1985.

The option price for an improved probability of availability of R (i.e., $\pi_1' \leq \pi_1$) would maintain that $P_{11} = P_{21} = 0$ (for a state independent payment) as in equation [12].

$$OP^* = E^*(\bar{0},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ R;\ \overline{EU}) - E^*(\bar{0},\ P_{12},\ P_{22};\ \pi_1',\ 1-\pi_1';\ R;\ \overline{EU}) \quad [12]$$

This is a special case of Simmons' (1984) risk premium and provides an alternative description of the option price concept recently discussed by Freeman.[19]

It also is possible to use this framework to define one concept of existence value in ex ante terms. Returning to the original framework of demand uncertainty, user values based on planned consumption, PCV, would be given as:

$$PCV = \tilde{E}(\bar{P}_{11},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ R;\ EU) - \tilde{E}(P_{11},\ P_{12},\ P_{22};\ \pi_1,\ 1-\pi_1;\ R;\ EU) \quad [13]$$

where P_{11} is the price for contingent commodity x_{11} where there is zero demand
Thus ex ante (or planned) existence values PEV would be:

$$PEV = OP - PCV \quad [14]$$

There are both general and specific implications for further taxonomic work in these types of values which follow from this new framework.

1. Concern over the motivations underlying existence values seems misplaced, because it is not clear that it is reflected in any tangible way in the relationships describing how households' decisions are affected by the presence of these motives. In terms of the goal of measuring existence values in either an ex post or an ex ante framework, the source of these values as a result of different types of motives does not seem to have observable implications.

2. A general, all encompassing, conceptual framework for describing values that arise from the use and the existence of the resource must first select a perspective for the analysis. Option value is not relevant to an ex post analysis of welfare changes.

3. To the extent a model that maintains there is uncertainty over the state of individual demand or over the conditions of supply is the most appropriate behavioral framework for analyzing policy decisions, then an ex ante perspective is the appropriate basis for benefit-cost analysis. In this context, the relationship between option price and the expected value of consumer surplus (i.e., the op-

[19]Freeman, A. Myrick III, "Supply Uncertainty, Option Price and Option Value is Project Evaluation," Land Economics, Vol. 61(May 1985):176-181.

tion value) is not relevant to the conceptual framework required for evaluating the policy action. Simmons (1984) proposed cost function (i.e., the planned expenditure function) is.

Measuring Intrinsic Values

Part of the motivation for the renewed interest in intrinsic values must be attributed to estimates of their magnitudes in comparison to user values for unique natural environments. For example, Schulze et. al. (1983) found estimates of preservation values for visibility at the Grand Canyon between $34 and $52 across four cities in their contingent valuation study.[20] When aggregated over all households in the U.S., these estimates implied a value of visibility at the Grand Canyon in the billions of dollars. The portion of this estimate attributed to user values was less than 0.5%. While not as dramatic a contrast in the sources of value, the available estimates of option value from other studies involving less well-known natural environments (many of which would not be considered unique) generally indicate that they are 40-50% of estimated user values (Fisher and Raucher 1984). These findings clearly contrast with Freeman's (1984) empirical bounds for option value in relation to the expected consumer surplus.

This disparity is not surprising. There has been some confusion in the literature on how the various types of benefits considered in an evaluation of decisions involving environmental resources relate to each other. Past efforts at estimating total resource values in the presence of uncertainty have tended to mix perspectives in their approach to valuation of the resource under study. For the most part, these empirical studies have been asking individuals questions that are too vague in comparison to the structure of the conceptual models proposed to explain individual behavior. Moreover, they have elicited responses within frameworks that were not consistent with the theoretical structure that was used to interpret them.

For example, consider the case of eliciting information on option value. The timeless framework for defining option price has been used in most of the contingent valuation studies involving option price bids.[21] Individuals have been asked valuation questions in two different ways. One approach elicits the option price directly, explaining the potential sources of values of a resource (e.g., the value card in the Desvousges et al. (1983) analysis of option prices for water quality improvements in the Monongahela River) and then asking for the amount expected to be due to use in the future. The second approach asks separately for user and option values (Greenley et al. and Walsh et al. 1984).

Both approaches have limited the information on types of uncertainty, time horizon, mechanism for resolving the uncertainty, opportunities that are available to the individual for adjustment to risk, etc., that have been communicated to the sample respondents. Clearly, one cannot "second-guess" the individual's prospects for using a resource in the future.[22] However, what is the "future" to each individual will vary. By adopting a timeless approach to option value, these studies have left the definition of the time horizon to the individual. This may not be inappropriate, if the individual appreciates that the decision must take account of future use over some relevant time horizon. However, to interpret the responses, relating them, for example, to independent estimates of user values, we must know how these responses were formulated. In effect, what time horizon did each respondent consider as relevant to the specified option prices?

Equally important, the ability of individuals to separate components of intrinsic values may be especially difficult. What is attributed to option values may actually reflect existence values, if unobservable future uses are considered in the option price bid but not associated with in situ consumption. This seems to be a likely response, because the questions have tended to define use as in situ use. This conceptual analysis suggests that the contingent valuation questions have tended to ask for planned user values as defined in equation [13] rather than the expected consumer surplus as given in equation [5]. This interpretation follows because the time pattern of use has largely been left undefined. While in some cases information on actual use was elicited (Desvousges et al. 1983), this information did not, as a rule, provide the basis for estimates of user values.

Finally, in the real world individuals must consider many resources in their consumption activities. In many cases the actual "purchases" made of the services of these resources may be limited, especially when considered in relationship to the rest of the households' budgets. Responses to contingent valuation questions on any one of these resources have tended to leave to the individual the matter of forming expectations as to the availability of these other resources.

This discussion of the conceptual frameworks underlying and intrinsic values clearly suggests that these perceptions will influence individuals' valuation responses (i.e., these additional R's would enter both types of expenditure functions).[23] While some contingent valuation experiments have investigated the effects of other public goods on the bids given for specific resources, they have tended to use either general

[20]Preservation values are defined in this study in such a way that they have been interpreted as existence values (Randall and Stoll 1983) and as a combination of existence and option values (Schulze et. al. 1983.

[21]Greenley et al. (1981) mention the time of the activities in their descriptions of the user and option value questions; but the time dimension is not directly related to what is being requested of the survey respondents.

[22]We could, of course, pose as part of the description of the contingent commodity the uncertainty that would characterize an individual.s circumstances. This formulation would make the uncertainty a part of the hypothetical conditions presented to the individual.

[23]Brookshire et. al. (1985), have often referred to these effects using the Kahneman and Tversky (1982) framework of mental accounts. Namely, that individuals tend to partition their decisionmaking so that choices on particular goods and services only consider a subset of the commodity set. This seems completely analogous to the separability assumptions that under budget decomposability conditions in demand theory.

descriptions of the environmental resources involved or entirely different types of public goods. It is reasonable to expect that the more closely related resources will have larger effects on all dimensions of values, especially for resources that are not unique.

All these issues relate to the use of the contingent valuation approach for benefit measurement. The character of the description of the situation, terms of payment, and the nature of the commodity presented to an individual must be much more complex than it has been if we are to provide a tangible link between the resulting estimates and the theoretical arguments that motivated their development. This added complexity raises genuine questions as to the feasibility of applying the technique.

Nonetheless, estimation of intrinsic values need not be exclusively based on contingent valuation methods. Recent work incorporating risk measures as attributes of housing sites[24,25] suggests that indirect methods may provide a basis for valuing risk changes acquired through such site selections. These models can be used to estimate the incremental option price-risk relationship when the option price is assumed to be a payment for a change in the odds of some desirable state as in equation [12].[26] This approach is consistent with the ex ante perspective, and is relevant to the valuation of changes in the conditions of access for some environmental resources. However, it does not provide a basis for estimating ex ante existence values. Moreover, to interpret the incremental option price estimates, the analyst must understand how individuals perceive and respond to the risk changes that are assumed to be valued in the model.

Implications

Given the current state of knowledge, appeals to substantial existence or option values in excess of estimated user values in benefits analysis for natural or environmental resources that are not unique must be justified within a carefully designed conceptual framework that recognizes the *ex post ex ante* distinction. The failure of nearly all past empirical studies to appreciate this distinction in the design of their efforts to estimate intrinsic values, as well as problems in their specific interpretations of their results calls for caution in the use of all estimates of option and existence values.

Incorporating intrinsic benefits into routine benefit cost analyses, will require: (1) resolution of the perspective used in evaluating each policy decision in measuring the benefits and costs that would result from it; (2) consistent and realistic definition of existence values in relationship to that perspective and what is attributed to either actual or planned use; and (3) better understanding of the actual considerations individuals use in valuing resources and how they are communicated in either contingent valuation surveys or in the variables designated to represent the uncertainty and choice factors in indirect benefit estimation methods.

[24]Brookshire, David S., Mark S. Thayer, John Tschirhart, and William D. Schulze, 1985. "A Test of the Expected Utility Model: Evidence from Earthquake Risk," Journal of Political Economy, 93(Apr.):369 = 389.

[25]Harrison, David Jr. 1983. "Housing Values and the Willingness to Pay for Hazardous Wastes Regulations," Kennedy School, Harvard University, unpublished paper.

[26]Smith, V. Kerry "Supply Uncertainty, Option Price and Indirect Benefit Estimation," Land Economics, Vol. 61(August 1985):303-307.

References

Becker, Gary S. 1981. A Treatise on the Family. Harvard University Press, Cambridge, Mass.

Becker, Gary S. 1985. A Theory of the Allocation of Time. Economic Journal, 75(9):493-517.

Bishop, John and Charles Cicchetti. 1973. Some Institutional and Conceptual Thoughts on the Measurement of Indirect and Intangible Benefits and Costs. in Cost Benefit Analysis and Water Pollution Policy, Henry M. Peskin and Eugene P. Seskin, editors. The Urban Institute.

Bockstael, N.E. and K.E. McConnell. 1983. Welfare Measurement in the Household Production Framework. American Economic Review, 83(9):806-814.

Brookshire, David S., Larry S. Eubanks, and Alan Randall. 1983. Estimating Option Prices and Existence Values for Wildlife Resources. Land Economics, 59 1-15.

Cook, Phillip J. and Daniel A. Graham. 1977. The Demand for Insurance and Protection: The Case of Irreplaceable Commodities. Quarterly Journal of Economics 91:143-156.

Cummings, Ronald G., David S. Brookshire, and William D. Schulze. 1986. Valuing Public Goods: The Contingent Valuation Method (Rowman and Allanheld Publishers).

Desvousges, William H., V. Kerry Smith, and Matthew McGivney. 1983. A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvement. Environmental Benefits Analysis Series (Washington, D.C.: U.S. Environmental Protection Agency).

Fisher, Ann, and Robert Raucher. 1984. Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives in Advances. In Applied Micro-Economics, Vol III, V. Kerry Smith and Ann D. Witte, editors. (JAI Press, Greenwich, CT).

Freeman, A. Myrick III. 1979. The Benefits of Environmental Improvement: Theory and Practice (Johns Hopkins University, Baltimore, MD).

Freeman, A. Myrick III. 1984. The Sign and Size of Option Value. Land Economics 60:1-13.

Graham, Daniel A. 1981. Cost Benefit Analysis Under Uncertainty. American Economic Review 71:715-725.

Greenley, Douglas A., Richard G. Walsh, and Robert A. Young. 1981. Option Value: Empirical Evidence from a Case Study of Recreation and Water Quality. Quarterly Journal of Economics 95:657-673.

Haveman, Robert H., and Burton A. Weisbrod. 1973. The Concept of Benefits in Cost-Benefit Analysis: With Emphasis on Water Pollution Control Activities. In Cost Benefit Analysis and Water Pollution Policy, Henry M. Peskin and Eugene P. Seskin, editors. The Urban Institute.

Kahneman, Daniel and Amos Tversky. 1982. The Psychology of Preferences Scientific American p. 160-180.

Krutilla, John V. 1961. Welfare Implications of Benefit Cost Analysis. Journal of Political Economy 69:226-235.

Krutilla, John V. 1967. Conservation Reconsidered. American Economic Review 57:777-786.

Krutilla, John V. and Anthony C. Fisher. 1975. The Economics of Natural Environments. Johns Hopkins University Press, Baltimore, MD.

Mäler, Karl Goran. 1974. Environmental Economics: A Theoretical Inquiry (Johns Hopkins University, Baltimore, MD).

McConnell, Kenneth E. 1983. Existence and Bequest Value. In Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas, Robert D. Rowe and Lauraine G. Chestnut, editors. Westview Press, Boulder, CO

Randall, Alan and John R. Stoll. Existence Value in a Total Valuation Framework. In Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas, Robert D. Rowe and Lauraine G. Chestnut, editors. Westview Press, Boulder, CO.

Schulze, William D., David S. Brookshire, Eric G. Walther, Karen Kelley MacFarland, Mark A. Thayer, Regan L. Whitworth, Shaul Ben-David, William Malm, and John Molenar. 1983. The Economic Benefits of Preserving Visibility in the National Parklands of the Southwest. Natural Resources Journal 23:149-173.

Simmons, P.J. 1984. Multivariate Risk Premia With a Stochastic Objective. The Economic Journal Supplement, Conference Papers from Annual Conference of Royal Economic Society, 94.

Smith, V. Kerry. 1976. The Treatment of Intangibles in Benefit-Cost Analysis. In Environmental Control Newsletter 4, No. 5.

Smith, V. Kerry. 1981. Introduction to Advances in Applied Microeconomics and Some Perspectives on Volume I. In Advances in Applied Micro-Economics, Vol. I, (JAI Press, Greenwich, CT).

Smith, V. Kerry. 1984. Option Value: A Conceptual Overview. Southern Economic Journal 49:654-668.

Smith, V. Kerry. 1984. A Bound for Option Value. Land Economics 60:292-296.

Walsh, Richard G., John B. Loomis and Richard A. Gillman. 1984. Valuing Option, Existence and Bequest Demands for Wilderness. Land Economics 60: 14-29.

Weisbrod, Burton A. 1964. Collective Consumption Services of Individual Consumption Goods. Quarterly Journal of Economics 78:471-477.

Uncertainty and Resource Valuation: Theoretical Principles for Empirical Research

Richard C. Bishop[1]

Abstract--Empirical research on resource values should apply the concept of option price. Option price includes both the expected value of future use and option value, where the latter represents a positive or negative adjustment for the effects of uncertainty on utility. However, additional basic research on the magnitude of option value may have large implications for benefit-cost analysis using market values.

This paper reviews the theoretical literature on option value in order to identify principles that can be applied in empirical research on natural resource values. Suppose a study is being designed to place an economic value on a wildlife resource. The first step would be to focus on current users. These might include both "consumptive users" -- hunters or anglers -- and "nonconsumptive users" -- viewers, photographers, etc. A sample of such users could be surveyed to establish monetary values by applying the travel cost method or contingent valuation. However, both economists and noneconomists have asked whether such user values, taken alone, might underestimate the total economic contribution of wildlife and other resources.

One line of reasoning is that people who are not current users and who would not be counted in the user survey, might place a significant value on the option of using the resource in the future. Such options would have value to people, because they are uncertain about future economic parameters, such as preferences, income levels, and resource availability. This "option value" is the focus of this paper.

Weisbrod (1964) published one of the first articles on option value. Bishop (1982) summarized the evolution of the concept. Other recent contributions include Graham (1981), Hartman and Plummer (1987), Smith (1983, 1984), Freeman (1984, 1985) and Chavas et al. (1986). The literature on option value often is very technical and confusing. Researchers need to know what these theoretical contributions imply for valuation studies. The first step is to develop the definitions needed to examine the problem of welfare measurement under uncertainty. Then the theoretical and practical appropriateness of various welfare measures will be examined, with particular emphasis on the concept of option price.

Option price is defined as either the maximum willingness to pay of consumers to maintain the option of future use or the minimum compensation required to give up the option. For uncertain consumers, option price includes both the expected economic value of future use and option value; the latter is a positive or negative adjustment reflecting the effects of uncertainty on utility. Some attention also will be given to a different concept associated with maintaining future options, the so-called "quasi-option value," as developed by Arrow and Fisher (1974) and Henry (1974).

A second kind of value also may be present among current non-users. There may be people who are not present users and who do not anticipate becoming users in the future, who, nevertheless, would place a value on the continued existence of a resource. Such existence values are not treated here (Krutilla 1967, Krutilla and Fisher 1975, Randall and Stoll 1983, McConnell 1983, Fisher and Raucher 1984, and Boyle and Bishop 1987).

Appropriate Measures in Cost-Benefit Analysis

The easiest way to define the problem to be confronted here is to develop in detail the hypothetical example posed earlier. Suppose that a study is being conducted to value a wildlife resource (e.g., an elk herd within a given area of national forest). The context might be a proposed mining project that would eliminate habitat necessary to the elk herd's survival. Also, suppose that, based on a user survey, contingent valuation and/or a travel cost model are used to estimate the present period consumer surplus of users. After expanding the study results to the population of present users, the estimated

[1]Professor, Department of Agricultural Economics, University of Wisconsin-Madison.

annual value of the elk herd to all present users is determined. Assume for the sake of discussion that this estimate is accurate.

Next, suppose that Mr. Citizen steps forward to argue that his value for the elk herd was overlooked. He was not a user in the present period and was not counted in the user survey, but indicates that he may become an elk viewer in the future and would be willing to pay $100 right now to be certain that this elk herd will be available in the future. What should be done with this $100 value? Should it be added to present benefits, to future benefits, or should it be ignored?

Building more detail into this scenario, let's ask Citizen to provide more information. Why would he pay $100 now? Suppose that he is uncertain about whether he will actually make an elk viewing trip in the future. If he decides to go, he will get $175 in consumer surplus. If he decides not to go, then his future consumer surplus from the elk herd will be zero. The decision about whether or not to make the trip depends on whether he can persuade a specific friend to go. Right now, he figures that the chances are about even that his friend will agree to accompany him. To keep it simple, suppose that the friend is a marginal elk viewer in the sense that she will not derive any consumer surplus from elk viewing whether she agrees to make the trip or not.

Citizen's bid of $100 is his "option price." It represents his maximum willingness to pay in the present for the option of viewing elk in the future. It is what is termed an "ex ante value." Ex ante values are payable in the present for possible use in the future. They are determined while consumers may be uncertain about future preferences, income levels, resource availability, or other economic parameters. Citizen's "conditional consumer surplus" values of $175 if he goes elk viewing in the future and zero if he does not are "ex post values." They are determined after the uncertainty has been resolved and are, at present, conditional on the state of the world.

Ex ante values (option prices) and ex post values (conditional consumer surpluses) are alternative welfare measures. Citizen would be willing to pay $100 now for the option of viewing elk in the future or he would be willing to sign a contract to pay either $175 or zero in the future conditional on his decision to take a trip or not to take a trip. Given the even odds of his taking a trip, a third alternative welfare measure, the "expected value of consumer surplus" is 0.5($175) + 0.5(0) = $87.50.

The third welfare measure, expected consumer surplus, has played a central role in the option value debate. Because option price and the expected value of consumer surplus are alternative monetary expressions of the same possible levels of utility, it would make no sense to add them. Citizen's value of future elk viewing opportunities is not $187.50 (option price plus expected consumer surplus). To commit this error would be to fall into a double-counting trap first recognized by Long (1967). The monetary measure of value is either $100, if the ex ante measure is the correct welfare measure or $87.50 if the expected value of the ex post measures is chosen. Stated differently, Citizen would not both pay $100 now and sign the contract for ex post payments of $175 or zero. The issue becomes one of identifying which measure is correct.

Option price and expected consumer surplus need not be equal. The difference between option price and expected consumer surplus ($100 - $87.50 = $12.50) is "option value" which can be interpreted as an ex ante allowance for the uncertainty that Citizen has about whether the trip will occur. Furthermore, while this paper's discussion has been cast in terms of consumer surplus, all the definitions are easily translated into "exact" welfare measures (Schmalensee 1972).

To reiterate, three distinct potential measures of the value Citizen places on elk viewing opportunities have been identified: (1) option price; (2) conditional, ex post consumer surplus values, one for each possible future state of the world; and (3) the mathematical expectation of the ex post consumer surplus values. The problem is to decide which measure to use in cost-benefit analysis. To develop a proposed solution to this problem, it will be necessary to inquire more deeply into the welfare theoretical basis of cost-benefit analysis.

Cost-Benefit Analysis Under Uncertainty

The welfare theoretical justification for comparing benefits and costs is the potential Pareto improvement criterion. The cost-benefit analyst is asking whether the "gainers" from a proposed project or policy could compensate the "losers." This criterion is termed the "compensation test." Note that the compensation test makes no presumption about whether compensation is actually paid. It is often noted that the analyst should develop information on the "distributional implications" of the decision; but whether compensation of losers is actually accomplished is left to non-economists.

Current practice is to conduct this exercise as if gainers and losers are operating under certainty. Early writers (Eckstein 1965) did advocate adjustments in the discount rate to reflect the greater relative uncertainty of some projects. This has continued to be a controversial suggestion, and more recent writers (Arrow and Lind 1970, Graham 1981, Chavas et al. 1986) have tended to strengthen the theoretical arguments for the riskless rate of discount. Thus, the theory of cost-benefit analysis under uncertainty tends to focus more directly on the compensation test itself (Ulph 1982). How should the compensation test be applied when gainers and losers are uncertain?

One possibility is termed the "ex post compensation test." According to this criterion, a project or policy is deemed economically feasible if the gainers can fully compensate the losers in all states of the world. That is to say, the analyst would estimate the benefits and costs in each and every state of the world, and judge the project or policy as having passed the ex post compensation test only if net benefits are positive in all possible future states of the world.

Another possibility is the "ex ante compensation test." Ex ante gainers are those with higher expected values of utility, while the opposite would hold for ex ante losers. The ex ante

compensation test examines whether ex ante gainers can compensate ex ante losers. Stated differently, the ex ante compensation test asks whether the aggregated option prices of ex ante gainers in terms of willingness to pay exceeds the option prices of ex ante losers in terms of willingness to accept compensation.

The third possibility is termed the "expected compensation test." Letting ex post willingness to pay be measured in a positive direction and ex post compensation demanded be measured as negative, gainers under this test will have positive expected values of ex post economic surplus while losers will have negative expected values. A project or policy passes the expected compensation test if the sum of these expected values across all gainers and losers is positive. This test boils down to requiring that "on the average" ex post gainers can compensate ex post losers.

This list of three possible compensation tests does not exhaust all possibilities. In fact, in the next section, a fourth possible measure of value based on the "fair bet point" is considered. Here, it is argued that the ex ante compensation test is preferred among the three possibilities just listed.

The ex post test has practical shortcomings. It is likely to be difficult to evaluate benefits and costs in all conceivable future states of the world. However, for many projects and policies it will not be necessary to do so. All that is required to reject a proposal is to find one plausible future scenario with negative net benefits. Therefore, probably only a few proposals would have to be considered in detail. Practical applications of the ex post compensation test could involve acceptance of proposals only if they have positive net benefits over a wide range of plausible future scenarios.

Objections to the ex post compensation test are at least as much conceptual as practical and can be stated as a rhetorical question. "Would society want to reject all projects for which there exists one or more plausible future scenarios with negative net benefits?" Such a rigorous criterion could introduce the same sort of paralysis that would exist under certainty if the full Pareto criterion were applied. Under the full Pareto criterion, proposals would be adopted only if they would make at least one member of society better off and leave no one worse off. Such a criterion would mean rejection of most, if not all, proposed policies and projects. The compensation test was developed to recognize explicitly that society may wish to accept proposals even though some people may be left worse off. Thus, the compensation test, with an explicit caveat that distributional effects also should be considered, has become the norm.

Similarly, society may wish to proceed with proposals that entail a risk of negative net benefits in some plausible future states of the world. Both the ex ante test and the expected compensation test are consistent with this less conservative view.

In choosing between the ex ante and expected compensation test, the former seems more appropriate. The ex ante test reflects tastes and other economic parameters at levels that exist when the decision is being made (Ulph 1982). The expected compensation test neglects the fact that proposals not only provide goods and services, but also affect people through the uncertainty they feel. Ex ante measures (i.e., option prices), include adjustments for this uncertainty. This adjustment is option value.

Therefore, out of the three welfare criteria discussed so far, the ex ante compensation test is preferred. Its implementation in valuation research would involve the measurement of option prices. The caution regarding the examination of distributional effects still holds after uncertainty has been introduced. A second caution is also appropriate. Proposals that pass the ex ante compensation test and are judged to have acceptable distributional implications may still be rejected if, under some plausible future scenarios, unacceptably large negative ex post net benefits could occur. As with distributional effects, the judgment of unacceptable risks would be left to the social decision maker. However, it would be incumbent on the cost-benefit analyst to examine not only ex ante benefits and costs but also worst case scenarios. This approach to uncertainty goes back to the writings of Ciriacy-Wantrup (1952, 1985) and has been more recently advocated in the context of endangered species policy by Bishop (1978).

Theoretical Arguments for Ex Post Measures

Some theoreticians are not so willing to reject ex post measures. An important dimension of uncertainty and welfare has been neglected. Once uncertainty is introduced, there is the additional issue of the allocation of risks. A potential problem with basing cost-benefit analysis on option prices is that, by constraining consumers to the same payment regardless of the state of the world, opportunities to reallocate risks across states in ways that improve welfare are overlooked.

To see what is involved, it will be useful to introduce the willingness-to-pay locus (Graham 1981). Recall that Mr. Citizen is indifferent between paying the option price ($100) with certainty and signing a contract to pay his consumer surplus (zero or $175), conditional on the state of the world in the future. Other contingent ex post payments may be equally satisfactory in the sense that they yield equal expected utility. For example, Citizen might be equally happy to sign a contract to pay $25, even if he decides not to make the elk viewing trip, provided that he would be required to pay only $160 if he does make the trip. Other ex post payment combinations may be equally palatable. The locus of all payment combinations yielding the same expected value of utility as option price (including the conditional consumer surpluses) constitute the willingness to pay locus as illustrated in figure 1.

The vertical axis in figure 1 shows the payments that will be made if the elk viewing trip is demanded, while the horizontal axis expresses payments if the trip is not demanded. Point A is the option price, because it involves the same payment ($100) whether the trip is demanded or not. Point B represents the conditional consumer surplus values, a contract for ex post payments of $175 or zero depending on whether a trip is

demanded. Point C represents ex post payments of $160 or $25, depending on whether a trip is demanded. Connecting all points which are equally palatable to Citizen in terms of the expected value of utility forms Citizen's willingness-to-pay locus.

This graph can be used to review the relationship between option price and consumer surplus. The expected value of consumer surplus is shown as point D. In this case, option price is the larger of the two making option value (OE minus OD) positive. However, a different willingness-to-pay locus could yield the opposite sign for option value.

Furthermore, figure 1 illustrates the fact that option price and conditional consumer surpluses are only special cases of an infinite number of state dependent payments that Citizen would find equally acceptable. So far, we have only discussed three points on the locus--option price, the consumer surplus point (0, $175), and the point ($25, $160)--as well as one other point, ($87.50), the expected value of consumer surplus, which in this case lies inside the locus. Another point on the locus is potentially relevant for welfare evaluation, Graham's (1981) "fair bet point."

Suppose that it is desirable to maximize the expected value of ex post payments, $\bar{P}$. Let P^i (i = 1,2) be the state dependent payments where, in state 1, the trip is demanded, and in state 2 it is not. Let the probabilities of the respective states be π^i (i = 1,2). In the example, $\pi^1=\pi^2=0.5$; but, to be slightly more general, allow π^i to vary with $\pi^1+\pi^2=1$. Thus, the assumed objective is to maximize

$$\bar{P} = \pi^1 P^1 + \pi^2 P^2 \qquad [1]$$

subject to the willingness-to-pay locus. The latter can be defined with the help of state dependent indirect utility functions $U^i(Y)$ (i= 1,2) where $\bar{Y}$ equals income which is assumed to be Y regardless of the state of the world. All other variables in the indirect utility functions are constant and have

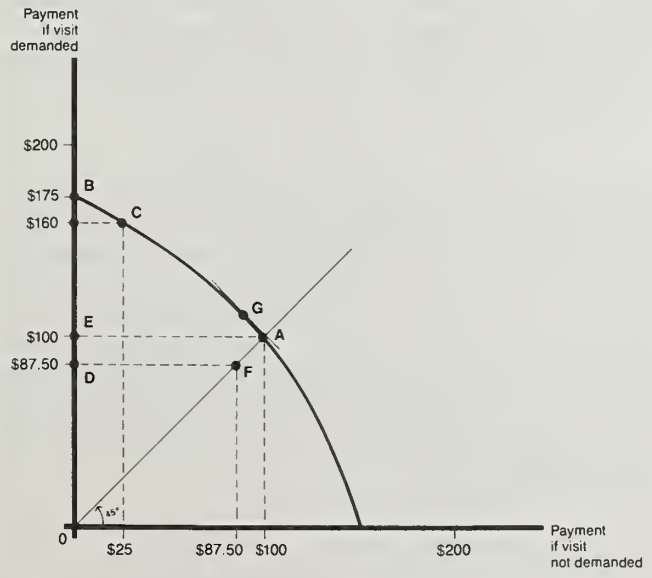


Figure 1.--Mr. Citizen's willingness to pay locus.

been suppressed for notational convenience. $U^i(Y)$ are the state dependent utility functions when elk viewing trips are available. Let $\bar{U}$ = the level of utility attainable if no elk viewing trips are possible because of mining development, which is assumed constant regardless of the state of the world. Then the willingness to pay locus is all combinations of P_1 and P_2 such that

$$\pi^1 U^1(\bar{Y}-P^1) + \pi^2 U^2(\bar{Y}-P^2) = \bar{U} \qquad [2]$$

Note in passing that consumer surplus P_s^i is defined by

$$U^i(\bar{Y}-P_s^i) = \bar{U} \quad (i=1,2) \qquad [3]$$

where, by assumption, $P_s^2=0$ for Mr. Citizen. Also, option price is defined by $P_o^1 = P_o^2 = P_o$ such that $\pi^1 U^1(\bar{Y}-P_o) + \pi^2 U^2(\bar{Y}-P_o) = \bar{U}$. Maximizing (1) subject to (2) and rearranging and simplifying the first order conditions indicates that at the maximum (assuming concavity of the $U^i(T)$),

$$U_y^i(\bar{Y}-P^1) = U_y^2(\bar{Y}-P^2) \qquad [4]$$

where U_y^i is the partial derivative of U^i with respect to income. Thus, the point that maximizes the expected value of ex post payments, denoted by (P_f^1, P_f^2), is that point on the willingness-to-pay locus where the marginal utilities of income in the two states are equal. This is the "fair bet point" (Graham 1981). Graphically, this point can be identified by first taking the total differential of [2] and rearranging to obtain:

$$\frac{dP^1}{dP^2} = -\frac{\pi^2 U^2(\bar{Y}-P^2)}{\pi^1 U^1(\bar{Y}-P^1)} \qquad [5]$$

which is the slope of the willingness-to-pay locus. This can be interpreted as the marginal rate of substitution between income in the two states. At (P_f^1, P_f^2), where conditional marginal utility levels are equal, the utility terms cancel leaving

$$\frac{dP^1}{dP^2} = -\frac{\pi^2}{\pi^1} \qquad [6]$$

Thus, at the fair bet point, the slope of the willingness-to-pay locus is equal to the negative of the inverse of the probabilities. This is shown as point of tangency G in figure 1 where the line tangent to the locus has a slope equal to the probability ratio on the right side of [6].

It follows from the definition of the fair bet point that the expected value of ex post fair bet payments is greater than or equal to the expected value of consumer surplus as well as option price, a conclusion with an intuitive interpretation. Suppose Mr. Citizen can obtain the option of taking the elk viewing trip by signing a contract for any combination of payments along the willingness-to-pay locus. The fair bet point is of special significance because it allows him to equalize the conditional marginal utilities of income across states. Application of this equamarginal principle would allow him to reallocate income between states by making state dependent payments in an optimal way. Thus, he is willing to pay more in

expected value terms to sign a contract for the ex post fair bet payments than for any other combination of payments, including the option price. At the fair bet point, Citizen achieves an optimal allocation of risk across states.

The fair bet point takes on even more significance in the context of competitive contingent claims markets. In such a set of markets, assuming (1) zero transactions costs, (2) large numbers of people with different state dependent utility functions who agree on the probabilities, and (3) smooth concave willingness-to-pay loci for everyone, consumers would exchange contingent commitments to pay given amounts until each arrives at a fair bet point on one of his or her willingness-to-pay loci. Thus, because probabilities are agreed upon by all, the marginal rates of substitution between income levels in alternative states will be equalized across consumers. (Note that each consumer will have a series of loci, one for each expected utility level.) In this way, a Pareto optimal allocation of risk among consumers would be established. It also turns out that the sum total of the willingness to pay of all consumers would be a constant across states, although it would not be clear which consumer would pay which amount until the state of the world became known. This point is worth considering, because it means that with perfect contingent claims markets it would be possible to know with certainty ex ante the aggregate willingness to pay of all citizens and this aggregate willingness to pay would be the same regardless of the state of the world that finally occurs. It also would be greater than or equal to aggregate option price and aggregate expected consumer surplus. These points are proven by Graham (1981).

These arguments mean that government might improve social welfare not only by altering the allocation of resources, but also by improving the allocation of risk. Perhaps this is already occurring to the extent that government fosters and regulates futures markets and private insurance and establishes public insurance programs for hazards such as flooding and crop failure. However, there appears to be little attention to seeking out improved risk sharing arrangements in the design of user fees for public projects. Perhaps research will identify new ideas for increasing the benefits and reducing the costs of public projects and policies through state dependent payment and compensation schemes.

Meanwhile, this framework would appear to be of limited relevance to applied research on resource and environmental values. For each gainer and loser to reach a fair bet point, either complete private contingent claims markets would have to be established or government would have to develop a repayment scheme that would imitate the market equilibrium. Mendelsohn and Strang (1984) argue that moral hazard, adverse selection, and the probable complexity of risks faced by real world consumers and producers make the evolution of such a set of markets unlikely. Furthermore, they argue, these same factors will form impediments to governmental implementation of payment schemes to attain fair bet points. Graham (1981) concluded that, "... option price may be regarded as a 'second best' measure of benefit appropriate to situations in which (1) actual financing involves sure collections from individuals, and (2) secondary contingent claims markets are not available."

As a practical compromise, the ex ante compensation test continues to be the appropriate foundation for applied cost-benefit analysis under uncertainty. In the example involving Citizen's elk viewing, option price is the best practical welfare measure. Additional research may identify ways to improve the allocation of risk among economic agents, but existing theoretical work in this area appears to be of limited relevance to applied research on resource and environmental values.

Quasi-Option Value

There is a second concept which is sometimes referred to as option value (Henry 1974; Hanemann 1983; Fisher and Hanemann 1986). However, this "second option value" is a very different concept from the one discussed so far. Arrow and Fisher (1974) and Conrad (1980) use the term "quasi-option value." This discussion of quasi-option value draws heavily on Hanemann's (1983) paper and adaptations in Fisher and Hanemann (1986).

Assume two periods, t = 1,2. In keeping with our elk watching example, assume that the mine can be initiated now (t = 1), in the future (t = 2), or not at all. Following Hanemann's (1983) exposition, let d_1 = the amount of mining development in the first period, $0 \leq d_1 \leq 1$, where unity here represents full development. Similarly, d_2 is the amount of mining development in period 2. Full development is an upper bound (i.e., $d_1 + d_2 \leq 1$), and we will assume that development is irreversible ($d_2 \geq 0$). Associated with development is some level of net benefits, B. For convenience, we can use the additive form:

$$B = B_1 + B_2,$$

where B_1 and B_2 are present and future net benefits, respectively. More complex forms are, according to Hanemann (1983), equally adaptable to the analysis that follows.

The function B takes into account all the benefits and costs of the decision. Thus, we can say that:

$$B_1(d_1) = B_{1d}(d_1) + B_{1p}(d_1)$$

where B1d(d1) is the first period mining benefits, net of investment and operating costs, as a function of the size of the mining project and B1p is first period elk viewing benefits, net of any costs for elk viewing facilities (e.g., parking lots, trails, etc.). These magnitudes are assumed to be known with certainty. Second period net benefits depend on the total level of development and the increment of development in the second period. Also assume that second period benefits depend on some random variable, θ, which has a known distribution. That is:

$$B_2(d_1 + d_2, d_2; \theta) = B_{2d}(d_1 + d_2, d_2; \theta) + B_{2p}(d_1 + d_2, d_2; \theta).$$

To illustrate quasi-option value, the traditional assumption (Arrow and Fisher 1974) is made that d_1 and d_2 are either 0 or 1. That is, partial development is not possible. Either the full mining project is implemented or it is not. Also, it will be assumed that, while θ is uncertain now, it will be known with certainty at the beginning of period 2. Suppose, though, that a mistaken decision maker fails to include in his or her calculations the fact that full information will be available before d_2 must be determined. Given the mistaken decision maker's assumption (i.e., no new information), the objective function can be stated, following Hanemann (1983) (see also Fisher and Hanemann 1986) as a two-stage decision problem of maximizing

$$V^*(d_1) = B_1(d_1) + \max_{d_2} [E\{B_2(d_1 + d_2, d_2; \theta)\}].$$

$$d_1 + d_2 \leq 1$$

$$0 \leq d_2$$

In contrast, a correct decision maker would include the forthcoming information in his or her decision calculus. The optimal value of d_2 can be determined with perfect information once $t = 2$ arrives and the correct decision maker's two-stage problem is to maximize

$$\hat{V}(d_1) = B_1(d_1) + E\{\max_{d_2} [B_2(d_1 + d_2, d_2; \theta)]\}.$$

$$d_1 + d_2 \leq 1$$

$$0 \leq d_2$$

Both V^* and $\hat{V}$ measure the expected value of total benefits over both periods as functions of d_1. The only difference is in the effects of the information assumption.

With the constraint that $d_t = (0, 1)$ for $t = 1, 2$, we can find the solution under each information assumption by comparing two values. For the mistaken decision maker,

$$V^*(0) = B_1(0) + \max \{E[B_2(0, 0; \theta), B_2(1, 1; \theta)]\}$$

$$V^*(1) = B_1 + E\{B_2(1, 0; \theta)\}$$

The decision would be based on whichever is larger. Thus, the solution is:

$$d_1^* = \begin{cases} 0 \text{ if } V^*(0) \leq V^*(1) \\ 1 \text{ otherwise} \end{cases}$$

For the correct decision maker, the comparison would be between:

$$\hat{V}(0) = B_1(0) + E\{\max [B_2(0, 0; \theta), B_2(1, 1; \theta)]\}$$

$$\hat{V}(1) = B_1(1) + E\{B_2(1, 0; \theta)\}$$

Thus,

$$\hat{d}_1 = \begin{cases} 0 \text{ if } \hat{V}(0) \leq \hat{V}(1) \\ 1 \text{ otherwise} \end{cases}$$

Note that because of irreversibility,

$$\hat{V}(1) = V^*(1).$$

If preservation is chosen by the correct decision maker, development can always take place in the second period if the information warrants it. New information prior to the beginning of the second period could not possibly reduce the expected value compared to the case of no new information and might lead to a higher expected value. In mathematical terms:

$$E\{\max [B_2(0, 0; \theta), B_2(1, 1; \theta)]\} \leq \max \{E[B_2(0, 0; \theta), B_2(1, 1; \theta)]\}.$$

This, in turn, implies that:

$$\hat{V}(0) \geq V^*(0).$$

Thus, the correct decision maker can achieve an expected value that is just as large or larger than the expected value attainable by the mistaken decision maker. It is also intuitive that the incentives not to develop (i.e., setting $\hat{d}_1 = 0$) are stronger for the correct decision maker. Preservation ($\hat{d}_1 = 0$) leaves her or him flexible to adapt to whatever θ turns out to be while $d_1 = 1$ is irreversible and commits her or him to the mine regardless of θ. The prospect of learning θ with certainty prior to deciding on d_2 is an incentive to keep the option open. Stated mathematically, the mistaken decision maker preserves if

$$V^*(0) - V^*(1) > 0$$

while the correct decision maker preserves if

$$\hat{V}(0) - \hat{V}(1) > 0$$

and

$$\hat{V}(0) - \hat{V}(1) \geq V^*(0) - V^*(1).$$

The correct decision maker has a larger incentive to preserve.

In this context, quasi-option value can be defined as a tax on the mistaken decision maker, levied if development is chosen in the first period, which is sufficient to make him or her behave like the correct decision maker. Letting τ represent this tax, it would be defined by

$$\hat{V}(0) - \hat{V}(1) = V^*(0) - [V^*(1) - \tau]$$

or, after rearranging and canceling equal terms

$$\tau = \hat{V}(0) - V^*(0).$$

The relationship between quasi-option value and the value of information can be seen here. Based on the assumption of no new information, the mistaken decision maker was only able to generate an expected value for preservation of $V^*(0)$ while the correct decision maker, recognizing that new information is in the offing, can attain an expected value for preservation which is just as high or higher [$\hat{V}(0)$]. The difference is quasi-option value. That is, another way to define quasi-option value is as the expected value of perfect information conditional on choosing preservation in the present (Hanemann 1983).

Though brief and somewhat stylized, this example illustrates two conclusions about quasi-option value. First, the framework of analysis from which it is drawn, with its explicit attention to irreversibility and changing information, may well contain the most important ideas for improving project evaluation in the recent literature. Cost-benefit analysts have implicitly assumed that all decisions are equally irreversible when, in fact, this is not the case. The current state of the art in applied cost-benefit studies makes the analysts into mistaken decision makers. The framework drawn upon to devise quasi-option value is potentially very rich in insights about correct project evaluation procedures, optimal timing of investments, and optimal levels of information gathering (Miller and Lad 1984). Further attention to these insights could revolutionize cost-benefit analysis.

The second conclusion is that the concept of quasi-option value itself is nearly useless for applied research on individual resource values. For example, it would make no sense to ask people in questionnaires what their quasi-option values are, even assuming one could word an understandable question to do so. Only respondents who are behaving like mistaken decision makers will have such values. Stating the same point somewhat differently, if the government has enough information to set τ, why doesn't it just give people the information?

Beginning from the other direction and asking people how large their quasi-option values would be if they were mistaken would not be helpful either. Results would be arbitrary in the sense that quasi-option value will change depending on how mistaken respondents are told to assume they are. Results would not be useful, because, as Hanemann (1983) has shown, quasi-option value becomes less and less meaningful as assumptions are dropped. Drop the assumption that $d_1 = (0,1)$ and quasi-option value may not be positive. Assume that while information improves over time, some uncertainty will remain and it is questionable whether quasi-option value can be defined in a meaningful way. Assume that active information gathering is possible and the meaning of the concept becomes even less clear.

Conventional cost-benefit analyses become questionable if different degrees of reversibility are present among the alternatives and new information appears to be in the offing. However, this should be addressed directly by procedures which emulate the decision processes of the correct decision maker and not by trying to measure quasi-option values and adding them to benefits. Freeman (1986) correctly argues that the level of analysis is, or ought to be, different for quasi-option value than for option value proper. The latter focuses attention on the individual economic agent as he or she evaluates alternatives under uncertainty. For quasi-option value, the focus ought to be on the public decision maker who is evaluating public policies or projects under uncertainty.

Returning to the quest for theoretically defensible practical welfare measures, note that, if ex ante gainers and losers are assessing the reversibility of the alternatives and informational prospects correctly, this will be reflected in their valuations. This would seem to reinforce option prices as the correct welfare measure.

Implications for Applied Research

The goal here has been to search the option value literature for theoretical principles to guide empirical research. The concept of option price embodies the principles being sought. It is the applied mirror image of the ex ante compensation test. The alternative of applying the ex post compensation test appeared to be too stringent to be useful in practice. Few if any proposals would have positive net benefits in each and every future state. Use of the expected value of the ex post welfare measures seemed to have little justification in welfare theory. If sufficient contingent claims markets could be established or imitated through public programs, the expected value of the fair bet point would have much to recommend it; but given the poor prospects for such markets, option price is a practical, second-best solution to the valuation problem. Furthermore, option price includes option value whether the latter is positive or negative, large or small. Finally, to the extent that policy alternatives entail different degrees of reversibility and prospects are good for improved information in the future, economic agents will take account of this in determining their individual option prices.

These conclusions can be applied directly in contingent valuation studies. They imply that contingent valuation questions should be directed toward the future. For example, if an environmental improvement project is being evaluated, the valuation question could ask for a hypothetical commitment, to be made before project completion, to pay a certain amount per year for the environmental improvement over the project life or some shorter period. For examples of past studies that correctly implement this procedure see Desvousges et al.,[2] and Brookshire et al. (1983).

The ex ante compensation test may create greater difficulties for cost-benefit analysis where contingent valuation is not applied. The market prices, which, except for well-understood market imperfections and income effects, reflect social welfare at the margin so nicely in a world of certainty, may not reflect ex ante willingness to pay and accept in an uncertain world.

The problem is not that market prices are necessarily ex post values. Smith (1985) argues that real estate values, wages for occupations with various levels of risk, and other such market prices can be interpreted as ex ante values. Thus, he suggests, it should be possible to derive marginal option prices from hedonic price equations. The problem is that clear division of values into ex ante and ex post values breaks down in the real world. It seems plausible that following Smith's logic would yield an ex ante values; but would they be the correct ex ante values?

[2]Desvousges, William H., V. Kerry Smith and Matthew P. McGivney. 1983. "A Comparison of Alternative Approaches for Estimating Recreation and Related Benefits of Water Quality Improvements." Washington: U.S. EPA-230-05-83-001, March.

Perhaps the issue can be most easily described through an example. Take a relatively straightforward cost-benefit problem involving electricity, a market good. Suppose the task is to evaluate a hydroelectric dam which, if funded, would be in operation in 1990. Suppose that Mr. Citizen will be a consumer of project electricity and that his demand for the present year is being evaluated as a first step toward projecting his benefits into the future. One can imagine both ex ante and ex post influences on Citizen's demand at various prices. For example, he may own an air conditioner which he turns on if the weather is hot and does not if the weather is cool. This is an ex post demand in the sense that his consumption is determined only after the state of the world (hot or cool) is known. In contrast, Citizen may leave an outside light burning to change the probability of burglary. Because the state of the world (burglary or no burglary) is not known when the electricity for the light is demanded, this must be considered an ex ante demand. In this way, both ex ante and ex post valuations of electricity are incorporated into Citizen's present electricity demand.

Now suppose Citizen's demand has been projected into the future and his willingness-to-pay from the project calculated. Assume for the sake of argument that the projections are accurate. Would the present value of this consumer surplus be an accurate measure of his option price? Applying the ex ante compensation test, we would want to ask whether the maximum willingness to pay of Mr. Citizen and others like him would cover the costs of the project. This willingness to pay would have to be evaluated ex ante, (e.g., in 1990), with actual demand to be registered in subsequent years. The option value literature seems to imply that these projected values, reduced to present values, would not be fully accurate measures option price. While the projected demands may reflect some ex ante considerations, they are, in a sense, not "ex ante enough". They do not reflect the same degree of uncertainty that Mr. Citizen faces in calculating his option price for future electricity payable in 1990.

In more general terms, then, market demands may not be fully accurate indicators of the option demands which would have to be measured to fully implement the ex ante compensation test. The lack of a full set of contingent claims markets may have ramifications for cost-benefit analysis that are far more serious than most people have recognized. If option prices are a second-best welfare measure then projected consumer surplus measures must be viewed as potentially inaccurate approximations of option prices. They may neglect option values--positive or negative--which reflect differences in the uncertainties consumers would face in arriving at an option price compared to the uncertainty that is reflected in their market decisions. The question then is, "How large are these inaccuracies likely to be?" Large inaccuracies may raise grave questions about the accuracy of cost-benefit analysis generally while small inaccuracies would mean that projected economic surplus values are adequate estimates of option prices.

This bring us back to option value. It was tempting earlier in this paper to discard option value as an irrelevant empirical concept, because it is option price that is relevant for policy. Now, one might well argue that empirical assessment of option value is a central issue in future attempts to refine cost-benefit analysis. Certainly previously cited contingent valuation studies and those to come in the future will play an important role here; but questions will continue to arise regarding the accuracy of contingent option prices and option values. Thus, Freeman's (1984) semi-empirical look at the sign and size of option value appears to be a pivotal work. The next logical step would be to move from plausible utility functions such as those used by Freeman (1984) to real world people, perhaps in a laboratory or field experiment. It is hoped that option value will turn out to be consistently small. Otherwise, a major rethinking of conventional cost-benefit analysis may become necessary.

Finally, future empirical work would do well to stress implementation of procedures that consider differences in the reversibility of alternative courses of action and prospects for new information. The parallels between conventional cost-benefit analysis and our "mistaken" decision maker are too stark to be ignored. Powerful steps to improve project design and timing and to incorporate active information gathering into the analysis may be in the offing. Such procedures could be directly relevant to many current issues including acid rain, nuclear versus conventional power generation, and hazardous waste disposal.

Literature Cited

Arrow, Kenneth J., and Anthony C. Fisher. 1974. Environmental Preservation, Uncertainty and Irreversibility. Quarterly Journal of Economics 88:313-19.

Arrow, Kenneth J., and Robert Lind. 1970. Uncertainty and the Evaluation of Public Investment Decisions. American Economic Review 60:364-378.

Bishop, Richard C. 1978. Endangered Species and Uncertainty: The Economics of a Safe Minimum Standard. American Journal of Agricultural Economics 60:10-18.

Bishop, Richard C. 1982. Option Value: An Exposition and Extension. Land Economics 58:1-15.

Bohm, Peter. 1975. Option Demand and Consumer's Surplus: Comment. American Economic Review 65:733-36.

Boyle, Kevin J., and Richard C. Bishop. (1987). The Valuation of Wildlife in Benefit-Cost Analysis. Water Resources Research 23:943-950.

Brookshire, David S., Larry S. Eubanks, and Alan Randall. 1983. Estimating Option Prices and Existence Values for Wildlife Resources. Land Economics 59:1-15.

Chavas, Jean-Paul, Richard C. Bishop and Kathleen Sergerson. 1986. Ex-Ante Consumer Welfare Evaluation in Cost-Benefit Analysis. Journal of Environmental Economics and Management 13:255-268.

Ciriacy-Wantrup, S.V. 1952. Resource Conservation: Economics and Policies. University of California Press, Berkeley and Los Angeles.

Ciriacy-Wantrup, S.V. 1985. Natural Resource Economics: Selected Papers. Richard C. Bishop and Stephen O. Anderson, eds. Westview Press, Boulder, CO.

Eckstein, Otto. 1965. Water-Resource Development: The Economics of Project Evaluation. Harvard University Press, Cambridge.

Fisher, Ann, and Robert Raucher. 1984. Intrinsic Benefits of Improved Water Quality: Conceptual and Empirical Perspectives. In Advances in Applied Micro-Economics, Vol. 3, ed. V.K. Smith and A.D. Witte. JAI Press, Greenwich, Connecticut.

Fisher, Anthony C., and W. Michael Hanemann. 1986. Option Value and the Extinction of Species. Advances in Applied Micro Economics, V. Kerry Smith, ed. JAI Press, Greewich, Conn.

Freeman, A. Myrick, III. 1984. The Sign and Size of Option Value. Land Economics 60:1-13.

Freeman, A. Myrick, III. 1985. Supply Uncertainty, Option Price, and Option Value in Project Evaluation. Land Economics 61:176-181.

Freeman, A. Myrick, III. 1986. Uncertainty and Environmental Policy: The Role of Option and Quasi-Option Value. Advances in Applied Micro Economics, V. Kerry Smith, ed. JAI Press, Greenwich, Conn.

Graham, Daniel H. 1981. Cost-Benefit Analysis Under Uncertainty. American Economic Review 71:715-25.

Hanemann, W. Michael. 1983. Information and the Concept of Option Value. University of California, Berkeley, Department of Agricultural and Resource Economics, Working Paper 228.

Hartman, Richard, and Mark A. Plummer. 1987. Option value under income and price uncertainty. Journal of Environmental Economics and Management 14:212-225.

Henry, Claude. 1974. Option Values in the Economics of Irreplaceable Assets. In: The Review of Economic Studies. Symposium on the Economics of Exhaustible Resources: 89-104.

Krutilla, John A. 1967. Conservation Reconsidered. American Economic Review 57:777-86.

Krutilla, John A., and Anthony C. Fisher. 1975. The Economics of Natural Environments: Studies in the Valuation of Commodity and Amenity Resources. The John Hopkins University Press for Resources for the Future, Baltimore, MD.

Long, Millard F. 1967. Collective Consumption Services of Individual Consumption Goods: Comment. Quarterly Journal of Economics 81:351-52.

McConnell, Kenneth E. 1983. Existence Value and Bequest Value. Managing Air Quality and Scenic Resources at National Parks and Wilderness Area. Robert D. Rowe and Lauraine G. Chestnut, eds. Westview Press, Boulder, CO.

Mendelsohn, Robert, and William J. Strang. 1984. Cost-Benefit Analysis Under Uncertainty: Comment. American Economic Review 74:1096-1099.

Miller, Jon R., and Frank Lad. 1984. Flexibility, Learning, and Irreversibility in Environmental Decisions: A Bayesian Approach. Journal of Environmental Economics and Management 11:161-172.

Randall, Alan, and John R. Stoll. 1983. Existence Value in a Total Valuation Framework. Managing Air Quality and Scenic Resources at National Parks and Wilderness Areas. Robert D. Rowe and Lauraine G. Chestnut, eds. Westview Press, Boulder, CO.

Schmalensee, Richard. 1972. Option Demand and Consumer's Surplus: Valuing Price Changes Under Uncertainty. American Economic Review 62:813-24.

Schmalensee, Richard. 1975. Option Demand and Consumer's Surplus: A Reply. American Economic Review 65:737-39.

Smith, V. Kerry. 1983. Option Value: A Conceptual Overview. Southern Economic Journal 49:654-88.

Smith, V. Kerry. 1984. A Bound for Option Value. Land Economics 60:292-296.

Smith, V. Kerry. 1985. Supply Uncertainty, Option Price, and Indirect Benefit Estimation. Land Economics 61:303-307.

Ulph, Alistair. 1982. The Role of Ex Ante and Ex Post Decisions in the Valuation of Human Life. Journal of Public Economics 18:265-276.

Weisbrod, Burton A. 1964. Collective-Consumption Services of Individual- Consumption Goods. Quarterly Journal of Economics 78:471-77.

Willig, Robert D. 1976. Consumer's Surplus Without Apology. American Economic Review 66:589-97.

Peterson, George L.; Sorg, Cindy F. 1987. Toward the measurement of total economic value. General Technical Report RM--148. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station; 44 p.

Considerable progress has been made in recent years in the valuation of non-priced goods. However, emphasis has been on those things most readily measurable. Valuation of wildlife benefits, for example, has aimed at consumptive, on-site recreation use (i.e., hunting and fishing). The danger in these partial estimates of value is that measuring only the on-site consumptive use of wildlife may presume to measure total value. This report examined the task of measuring of-site non-consumptive wildlife vaues by considering values that include: total vlaue, option value, existence value, quasi-option value, and bequest value. Discrepancies in definitions, measurement problems, and research needs are addressed in this collection of papers.

Rocky Mountains

Southwest

Great Plains

U.S. Department of Agriculture
Forest Service

Rocky Mountain Forest and Range Experiment Station

The Rocky Mountain Station is one of eight regional experiment stations, plus the Forest Products Laboratory and the Washington Office Staff, that make up the Forest Service research organization.

RESEARCH FOCUS

Research programs at the Rocky Mountain Station are coordinated with area universities and with other institutions. Many studies are conducted on a cooperative basis to accelerate solutions to problems involving range, water, wildlife and fish habitat, human and community development, timber, recreation, protection, and multiresource evaluation.

RESEARCH LOCATIONS

Research Work Units of the Rocky Mountain Station are operated in cooperation with universities in the following cities:

Albuquerque, New Mexico
Flagstaff, Arizona
Fort Collins, Colorado*
Laramie, Wyoming
Lincoln, Nebraska
Rapid City, South Dakota
Tempe, Arizona

*Station Headquarters: 240 W. Prospect St., Fort Collins, CO 80526